

JPRS-JST-94-022  
18 August 1994



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# ***JPRS Report***

# **Science & Technology**

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***Japan***

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# Science & Technology Japan

JPRS-JST-94-022

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**Tokyo Institute of Technology Develops New Way of Fabricating Ceramic**

43070101A Tokyo THE NIKKEI WEEKLY in English  
13 Jun 94 p 13

[Text]

**Method Has Promising Applications as Optical Material**

A new way of fabricating a ceramic that emits blue fluorescent light when exposed to sunlight or other sources of ultraviolet radiation has been developed by researchers at the Tokyo Institute of Technology.

The ceramic, calcium tungstate, has promising applications as an optical material, but the difficulties and costs involved in manufacturing films of the material have precluded commercial development to date.

The Tokyo Institute's group reports a simpler way of fabricating thin films of calcium tungstate that can be carried out at room temperature.

In the process, which resembles standard electroplating, a pair of tungsten electrodes are immersed in a bath of calcium hydroxide and a 30-volt current is passed between them. In the ensuing electrolytic reactions, the tungsten metal on the positive electrode is oxidized and reacts with hydroxide ions in the bath to produce tungstate ions. These react with calcium ions in the bath to produce micron-sized particles of calcium tungstate, which precipitate out onto the negative electrode as a thin ceramic film.

**Bright Light**

The ceramic films so created emit 450 nanometer near-blue light when exposed to ultraviolet light of around 250 nm. The light is bright enough to be seen indoors. Moreover, if the ceramic is cooled down to liquid nitrogen temperature at minus 196°C, the light can even be seen outdoors at midday, the researchers claim.

To date, the only known way of manufacturing calcium tungstate films has been to sputter the starting materials onto a substrate in a vacuum, and then to sinter the mixture at high temperatures of around 1,000°C. This is complicated, costly, and the ceramic tends to fracture when cooled back down to room temperature.

**Combustion Synthesis Technology for Metal-Ceramic Composite Production**

94FE0517A Tokyo CERAMICS JAPAN in Japanese  
Mar 94 pp 200-202

[Article by Osamu Odawara, Dept. of Electronic Chemistry, Tokyo Institute of Technology]

[Text]

**1. Introduction**

Both in Japan and overseas there is vigorous R&D underway on combustion synthesis as a rapid, economical way to synthesize promising high-fusion-point inorganic compounds without requiring an external heat source such as a high-temperature furnace. Combustion synthesis refers to the synthesis and structuring of compounds by the combustion of powders at high temperatures through a spontaneous reaction propagation that supplies the heat of formation. Techniques have also been presented in which not only the synthetic powder compounds but also the synthetic compounds behind the combustion wave have been molded by sintering or by melting and solidification.

In Japan as well there is active R&D not only to synthesize chemical compounds but also to obtain greater density, better bonding properties and better linings by combining the actions of, for example, high pressures and centrifugal force. R&D has also begun on the synthesis of composite materials by utilizing combustion synthesis in short-term micro-gravity environments, which recently became available in Japan. Methods proposed for combination with high pressure technology include the high-pressure self-burning sintering process and the spring compression simultaneous synthesis and molding process. These methods are devised so that constant pressure with respect to the change in volume of the products is maintained during combustion synthesis, which permits the use of existing high pressure equipment without major modifications, and thus we can expect wider utilization of these processes in the future. In addition, many kinds of technical combinations have been proposed, including the impact solidification process in which impact compression is used to induce combustion synthesis and make use of the heat it generates. There is also a process in which homogeneity and micronization of synthetic particles is achieved by using high pressure and ultrasonic waves on the powder mixture simultaneously.

One technique that utilizes the action of centrifugal force is the process in which centrifugal force is applied to molten products formed in a combustion reaction, and during the solidification process a ceramic layer with excellent bonding properties is formed on the inner surface of a metal pipe to create a composite pipe. R&D has progressed on this "centrifugal-thermit process," and in 1979 the process reached practical application. Recently research has been conducted using combustion synthesis of fine intermetallic compounds under the action of centrifugal force. In this article I present an outline of the centrifugal-thermit process.

**2. Centrifugal-Thermit Process**

**2.1 Principle**

In the centrifugal-thermit process a thermit reaction, which involves the reduction of metal oxides, is induced inside a metal pipe that is rotating at a high speed, and a

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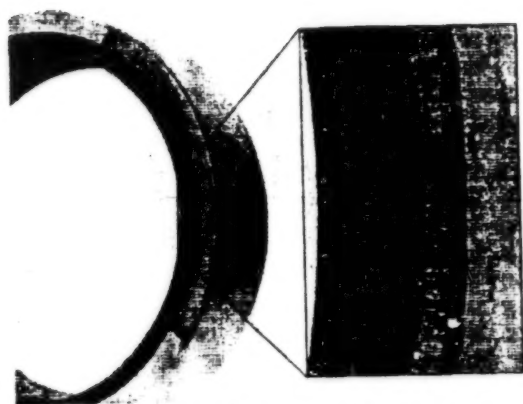


Figure 1. Cross Section Photo of Composite Pipe

thick-walled ceramic-metal layer is formed inside the pipe by the reaction products, which produces a composite pipe with excellent bonding properties. A typical thermit reaction involves the redox reaction between aluminum powder and iron oxide powder shown in Formula 1.



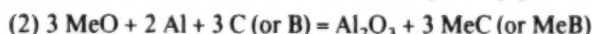
In this reaction 836 kJ of heat per mole of  $\text{Al}_2\text{O}_3$  are generated with the propagation of the reaction, and maximum temperature of the system, in other words the adiabatic temperature, in this reaction has been calculated to be more than 3500 Kelvins. Therefore, when a thermit reaction is induced inside a rapidly rotating pipe, the reaction products and the inside surface of the metal pipe melt together due to the heat generated by the reaction, the gases within the products are eliminated from the interior by the action of centrifugal force, and the reaction products are bound to the inside surface of the metal pipe at a uniform thickness. Because ceramics are generally less dense than metals, the product ceramic layer forms mainly toward the center of the pipe, and a product metal layer forms in the intermediate region between the metal pipe and the product ceramic layer. Thanks to the presence of this product metal in the intermediate area, the metal pipe and the product ceramic are strongly bonded together, and they form a composite pipe that is strongly resistant to thermal shock and to mechanical shocks from the outside.

During the course of this research to obtain a strong composite pipe, we have studied many factors (effects of centrifugal force, thermal insulation, atmosphere, environmental pressure, effects of additives, properties of reaction propagation and so on) and learned many things. Figure 1 shows typical cross-sectional photo of the composite pipe we have obtained.

## 2.2 Reaction Propagation Properties

With the present process it is possible to manufacture a long composite pipe of the 5.5 meter class in one process step by ignition at a single location. At present, there is no other known method for forming a seamless ceramic lining in this kind of long pipe. That is because from a technical standpoint this thermit reaction features rapid propagation along the interior surface of the thermit powder mixture, which is suspended in the air by the initial action of the centrifugal force, and then the reaction generally propagates in a radial direction.

The fact that the overall propagation of the reaction occurs in the radial direction has extended the length of metal-ceramic composite pipes formed in the past by the centrifugal-thermit process, and if carbon or boron is placed inward to the metal oxide (MeO)-aluminum powder mix, a second combustion synthesis reaction that follows the thermit reaction is induced, and it is possible to form a ceramic-ceramic composite pipe.



Therefore, when the above reaction is induced under centrifugal force, it is possible to make composites of carbide (or boride) and oxide due to the specific gravity differences of the products.

## 2.3 Distribution of Residual Stress in Composite Layers

The iron-alumina composite pipe obtained when iron is used for the outer metal pipe layer in the centrifugal-thermit process shrinks roughly 0.4% both in length and diameter compared with its dimensions before the reaction. Moreover, we have learned from heat shock test results that the inner ceramic layer remains sound without any damage such as cracking against a temperature difference of about 1000 Kelvins. To make this evaluation we studied the residual stress distribution in the composite pipe we obtained, and the results are shown in Figure 2. The tensile strength resides almost entirely in the intermediate metal layer, and the outer metal layer and inner ceramic product layer balance the stress. Moreover, because a compression force acts on the surface of the metal pipe outer layer, the expansion of the metal pipe outer layer does not act directly on the inner ceramic layer when the temperature rises, and the material remains sound even under sharp temperature gradients. This kind of residual stress distribution is difficult to achieve under equilibrium-theory processes, but can be obtained in non-equilibrium processes such as the centrifugal-thermit process. In other words, due to the sudden temperature increase from the inside and action of centrifugal force on the molten products, the metal pipe outer layer undergoes thermal expansion, but the interior of the pipe shrinks as the inner ceramic layer and the layer of metal product solidify, so the thermal expansion of the metal pipe outer layer is restricted. A compressive force acts on the ceramic layer during the course of cooling as a result of the difference in thermal expansion coefficients between the metal and ceramic, and in the same manner, a compressive force resides on the surface of the outer metal layer of the pipe.

## 2.4 Fields of Application

Because in the centrifugal-thermit process a combustion reaction propagation is induced inside a metal pipe and the reaction products are directly utilized to form a composite, it is difficult to exercise fine control over the reaction products. Therefore, compared with the manufacture of fine ceramics, in which the raw materials and manufacturing process are controlled with great sophistication, this method is crude, and that means the quality of the ceramic component is poorer. However, it retains the characteristic properties of ceramics, which otherwise cannot compete with metals in terms of hardness and strength at high temperatures. Moreover, it provides sufficient bonding strength between the ceramic and the metal pipe to form a strong composite pipe. This kind of stable composite structure results in a material that is very resistant to temperature, pressure, and shock from the outside. The most valuable properties of these pipes are their heat resistance, corrosion resistance and wear resistance. Possible practical applications include pipes for the transport of solid slurries and air, sliding mechanical parts subject to wear, high temperature and exhaust gas conduits, and pipes for transporting molten metals and salts. In circumstances requiring corrosion resistance, the range of applications will be limited by performance and cost, but in situations requiring a combination of functions the use of these pipes will be quite valuable.

## Conclusion

As mentioned above, when we consider the reaction propagation properties of the centrifugal-thermit process, it should be possible to create ceramic-ceramic

Fig. 2. Residual Stress Distribution in Composite Pipe

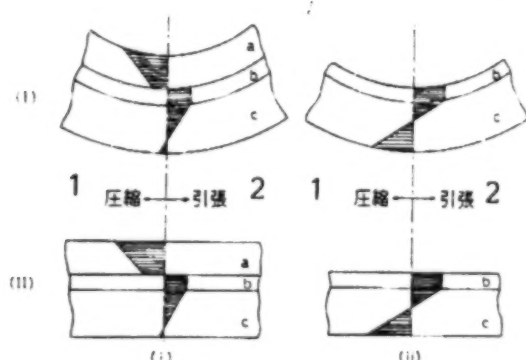


図2 複合構造管残留応力分布図

- 3 (I): 管径方向, (II): 管長方向  
(i): 3層状態, (ii): セラミックス層除去後  
(a: セラミックス層, b: 生成鉄層, c: 外層金属管)

Key: 1. Compression; 2. Expansion; 3. (I) Radial direction, (II) Axial direction, (i) 3-layer state, (ii) After removal of ceramic layer, (a: ceramic layer, b: product iron layer, c: metal pipe outer layer)

composite pipes by adjusting the positions of the reagent powders and so on. Moreover, it should be possible to form not only pipes but also various other shapes of composite material by utilizing the special features of the centrifugal-thermit process. When we look at the effect that external force has on (1) the movement of the individual particles of the reagent powders and the products, (2) the movement of the heat of formation in the reaction, and (3) the movement of the combustion wave, combustion synthesis is intriguing, not only from a practical standpoint but also in terms of fundamental observations. More specifically, the non-equilibrium reaction process known as combustion synthesis will provide an exciting area of research into the mutual interactions of the above three factors as we proceed toward practical applications in the future.

## Synthesis and Application of Intermetallic Compounds Produced by Combustion Synthesis Process

94FE0517B Tokyo CERAMICS JAPAN in Japanese  
Mar 94 pp 203-205

[Article by Yoshinari Kaieda, National Research Institute for Metals]

[Text]

## 1. Introduction

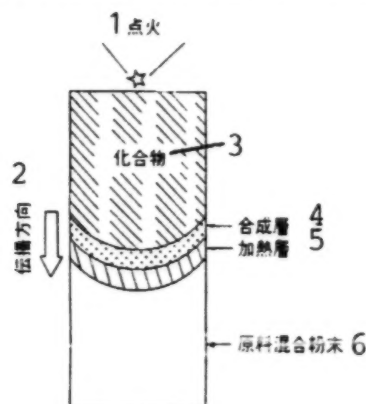
Recently, hopes have been rising for intermetallic compounds, but their actual use has been delayed. One reason is that almost all intermetallic compounds lack ductility, and very few seem suitable for practical use. Another reason is that these materials are difficult to manufacture. The former problem concerns the inherent nature of the materials, so it will be difficult to make fundamental improvements by improving manufacturing methods and so on. However, it is possible to adopt new manufacturing methods to overcome the latter. As one example, in this article I introduce a new method for manufacturing intermetallic compounds that uses elemental powders as raw materials and employs combustion synthesis as the basic chemical reaction.

## 2. History of Development of Combustion Synthesis

## 3. Principle of Manufacturing Intermetallic Compounds by Combustion Synthesis

In combustion synthesis compounds are formed by utilizing the heat of formation of two or more different types of substances. Figure 1 shows a schematic drawing of one application of this process. One edge of the mixture of powdered elements, which are the starting reagents, is intensely heated by an electrical discharge or other method to the ignition temperature  $T_1$  of the raw materials, which starts the reaction. The reaction begins at the point of ignition and generates a heat of formation.

Fig 1. Model of Combustion Synthesis Reaction



Key: 1. Ignition; 2. Direction of propagation; 3. Product; 4. Synthesis layer; 5. Heating layer; 6. Reagent powder mixture.

This heat of formation then heats up the area surrounding the point of ignition to the ignition temperature  $T_1$ , which continues the chemical reaction. The reaction is thus propagated as a result of this chain reaction process, and ultimately all the reagents are converted to products. The reader is referred to other studies for more detailed explanations of the basic thermodynamics, heat of formation, adiabatic temperatures,

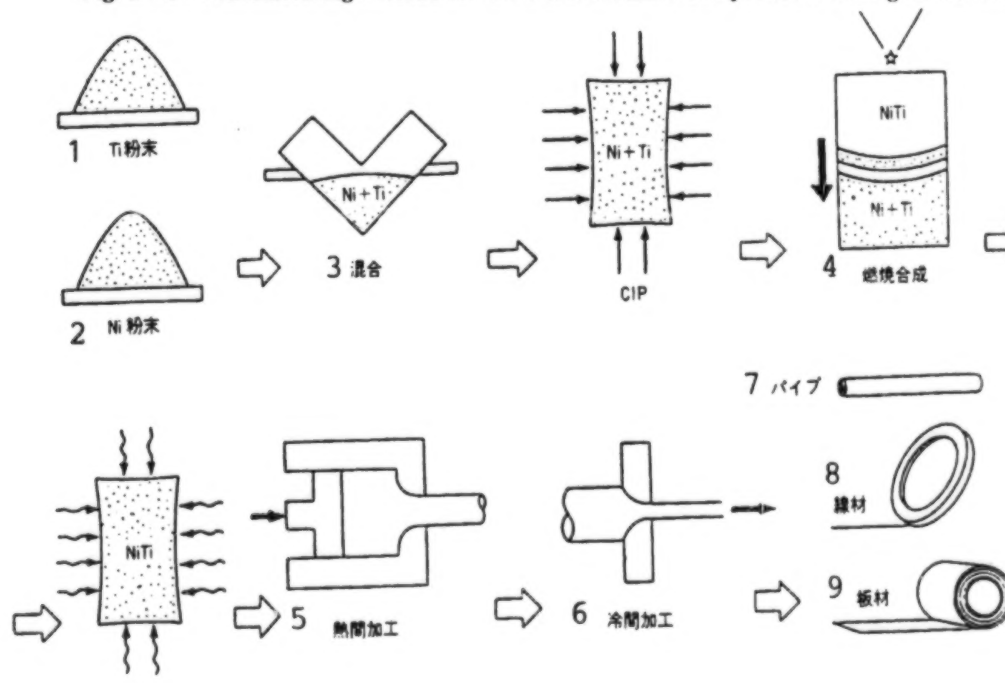
combustion synthesis wave propagation and so forth. However, practical intermetallic compounds cannot be formed with this kind of simplistic process.

#### 4. Manufacturing Technique for TiNi Intermetallic Compounds

Among the many intermetallic compounds, TiNi is exceptionally ductile and is a special material that exhibits shape-memory properties. The transition temperature for this material changes by as much as 10-20°C with a difference of as little as 0.1% in the nickel composition. Therefore, precise control of the composition and uniformity are essential during melting and casting. However, because titanium and nickel differ greatly in melting point and specific gravity, gravity segregation occurs easily and it is difficult to obtain a uniform material that has exactly the same transition temperature throughout. Moreover, the functions of shape-memory materials require that they be utilized as fine wires or sheets, so it must be possible to perform plastic processing on the smaller dimensions of the material.

Figure 2 shows the process we have developed to solve these problems. In this manufacturing process, the reagent powders are precisely mixed to yield the desired composition ratio and molded by cold isotropic pressurization (CIP). Then combustion synthesis is performed to convert the reagent powders to the product compound. The synthesized TiNi is solidified and sintered by HIP into an ingot with a relative density of 100%.

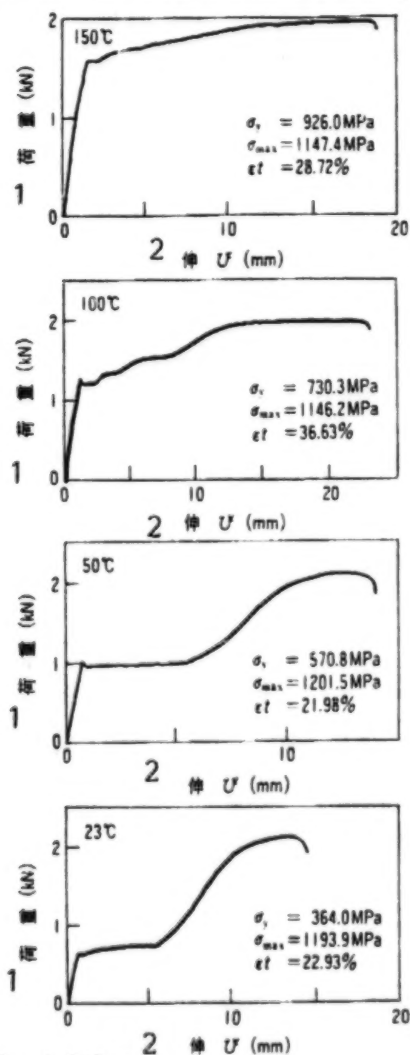
Fig. 2 New Manufacturing Method for TiNi Intermetallic Compounds Utilizing Combustion Synthesis



Key: 1. Ti powder; 2. Ni powder; 3. Mixture; 4. Combustion synthesis; 5. Hot processing; 6. Cold processing; 7. Pipe; 8. Wire; 9. Sheets.

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Fig. 3 TiNi Load-Stretch Bent Wire at Various Temperatures



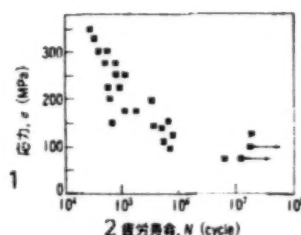
Key: 1. Load; 2. Stretch.

After hot plastic processing such as forging, extrusion, rolling and so on is performed at 1000°C, the material is cold-drawn into wires of 8.0 mm to 10  $\mu$ m in diameter. Actual manufacturing is done in 80 kg batches, and about 15 tons of high-performance TiNi intermetallic compounds are produced annually.

Figure 3 shows one example of characterization of the final product of a load-stretch bent wire at various temperatures when the  $A_f$  temperature of the wire is 20°C. Figure 4 shows fatigue test results for the same sample.

There is no gravity separation because of the specific gravity differences between titanium and nickel, and a homogenous material can be manufactured in methods that employ combustion synthesis, so an exact transition temperature can be realized. Moreover, the material has

Fig. 4 Results of TiNi Material Fatigue Tests



Key: 1. Stress,  $\sigma$  (MPa); 2. Fatigue life,  $N$  (cycle)

excellent hot and cold working properties, and it is well suited to mass production of high performance TiNi shape-memory intermetallic compound wires and other products.

#### 5. Development of Manufacturing Techniques for Other Intermetallic Compounds

Most intermetallic compounds, including TiAl, NiAl, Ni<sub>3</sub>Al, CoAl, and FeAl can be manufactured using the first part of the process shown in Figure 2. However, because almost none of these are suitable for plastic working, after HIP they are finished by machining. Among these, TiAl intermetallic compounds have shown great promise as lightweight, heat-resistant structural materials, but the melting points of titanium and aluminum differ by 1000°C, they react strongly with the crucible, and they are not very ductile so they are known as a material that is difficult to manufacture with current processes. Figure 5 [not reproduced] shows a TiAl ingot (diameter 80 mm, length 400 mm) and a sheet (thickness 6 mm, width 85 mm, length 500 mm) after combustion synthesis and vacuum sintering. The special characteristics of this method make this kind of product easy to manufacture.

#### 6. Conclusion

With manufacturing methods that employ combustion synthesis not only can intermetallic compounds be manufactured in bulk, but high performance final products in shapes such as wires, sheets, and pipes can be manufactured from materials suitable for plastic processing. At present the production of TiNi intermetallic compounds is underway on an industrial scale, and the amount of production has increased considerably. The TiAl intermetallic compounds manufactured with this method are used as bulk materials, and they are also being tested in powder form as raw materials for flame coatings and composites.

Most intermetallic compounds can be manufactured by combustion synthesis, but currently the only ones being manufactured in amounts with industrial significance are the TiNi intermetallic compounds for which there is an actual demand. A lot of basic research on combustion

synthesis is underway, but the only place where combustion synthesis is actually used for the manufacture of intermetallic compounds on an industrial scale is Japan, and the level of technology here is quite high.

### Materials Bonding by Combustion Synthesis

94FE0517C Tokyo CERAMICS JAPAN in Japanese  
Mar 94 pp 206-208

[Article by Manshi Ohyanagi, Faculty of Science & Technology, Ryukoku University]

[Text]

#### 1. Introduction

Combustion reactions in which at least one of the reagents is a solid have gradually begun to attract attention recently from materials researchers. The residues from this so-called "solid combustion" are ceramics, intermetallic compounds and composites that have potential as important industrial materials. Solid combustion reactions generally release a large amount of heat. In reactions that release a sufficiently large amount of heat, that heat can sustain rapid propagation of the reaction at the edge of the combustion, and after ignition there is no need to supply additional heat from the outside. The synthesis of materials that employs this process is called combustion synthesis. In this article I will discuss the bonding of unlike materials, which is a new development in applied research that focuses on the high heat of reaction generated by combustion synthesis.

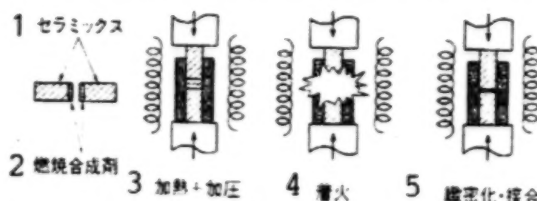
#### 2. Bonding of Unlike Materials and Combustion Synthesis

The bonding of unlike materials, typified by ceramic-metal composites, is an essential part of the development of composite materials, and it is being widely studied. More specifically, the chemical bonding processes that accompany the diffusion of elements at the bonding interface, the formation of solid solutions, and the formation of products in these reactions are an appealing field of research leading toward the practical application of combustion synthesis, in which a large amount of heat is released instantaneously.

Generally, in the chemical bonding of unlike materials that have large differences in their thermal expansion coefficients, a long time is required for the cooling process after bonding occurs at high temperatures in order to alleviate the stress that is generated at the bonding interface. Therefore, the concept of instantaneous bonding is not easily envisioned. When combustion synthesis is employed for the bonding, however, if the unique properties that characterize this process such as rapid heating and cooling are used advantageously, it is possible to obtain instantaneous bonding with bonding mechanisms unlike any we have seen in the past.

If we roughly classify several recent studies that employ combustion synthesis for bonding in ceramic-metal and ceramic-ceramic systems, we find three types of situations:

Fig. 1 Schematic Drawing of Ceramic-Metal Bonding by Combustion Synthesis Under Compression



Key: 1. Ceramic; 2. Combustion synthesis agent; 3. Heat and pressure; 4. Ignition; 5. Compacting and bonding.

(1) The combustion synthesis products form the main structural components of the bond itself;

(2) The combustion synthesis products are sandwiched between the bodies to be bonded; and

(3) The combustion synthesis products do not contribute directly to the bond; in other words, the great amount of heat generated by the reaction is used merely as a heat source for the bonding.

Due to space limitations, in this article I will discuss two examples: one of instantaneous bonding under compression, and one of instantaneous bonding under normal atmospheric pressure that utilizes this short-term process to full advantage.

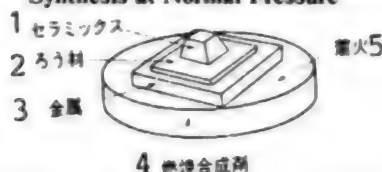
#### 2.1 Combustion Synthesis Bonding Under Compression

This is a method in which a combustion synthesis reaction is induced by a short-term heating process at ceramic-ceramic or ceramic-metal interfaces to bond them together. Figure 1 is a schematic drawing of this method. Ceramic-ceramic or ceramic-metal bonding is achieved through the reaction products of combustion under compression. This occurs because of the high temperatures from the exothermic reaction of the combustion synthesis reagents sandwiched between the bodies to be bonded. Compression methods include uniaxial or hexagonal compression, or the granular solid compression method employed in the former Soviet Union that utilizes casting sand and other particulates. In the case of ceramic-ceramic bonding, a powdered mixture of titanium, carbon and nickel is used as the reagent bonding material between two silicon carbide bodies. This is the method of bonding shown in Figure 1. In the case of ceramic-metal bonding, powdered mixtures of nickel and aluminum (or other mixtures that form intermetallic compounds) are used as the reagent bonding material.

#### 2.2 Normal Pressure Combustion Synthesis Process

This is a method to form a ceramic-metal bond at normal pressure by a localized, instantaneous heating process. Here I will introduce a case in which activated metal brazing material is used as a bonding medium. Figure 2 shows schematically a typical, simple case of

Fig. 2 Ceramic-Metal Bonding by Combustion Synthesis at Normal Pressure



Key: 1. Ceramic; 2. Brazing material; 3. Metal; 4. Combustion synthesis reagent; 5. Ignition.

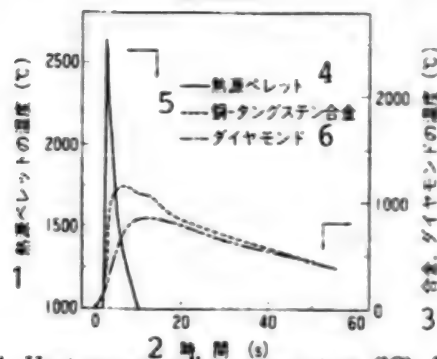
ceramic-metal bonding. In this bonding, ceramic, brazing material, and a metal base are stacked in descending order on a pellet (such as titanium and carbon) that will be used as a heat source for triggering the combustion synthesis reaction. The heat for the brazing is obtained by inducing the combustion synthesis reaction. This method can also be used for diamond-cemented carbide, diamond-(copper-tungsten) alloy, diamond-high speed steel and for aluminum nitride-copper and aluminum oxide-cemented carbide bonding. As shown in Figure 2, with this method reaction conditions must be selected so that the combination of the atmosphere and the pellet generating the heat do not make it hard for the reaction to occur, or conversely, so that bonding does not occur with the metal base. For example, melting of the metal accompanies thermit reactions, so direct heating from beneath the metal base is not suitable in those cases. Desirable reaction systems are those like titanium carbide in which the reaction in the combustion band is over in about 0.3 seconds, the molten substances produced in such a short time do not flow, and everything is converted to solid reaction products.

### 3. Diamond-Metal Instantaneous Brazing

Because of their great hardness and wear resistance, diamond tools are used to machine materials that are otherwise difficult to cut. These include non-ferrous metals like Al-Si, ceramics, and various types of composites. Recently a method has been developed for directly brazing gas-phase-synthesized diamond films and monocrystalline diamonds (including natural diamonds) onto a supporting shank. Tools manufactured by this brazing method offer many advantages such as the fact that they have very strong adherence and that repolishing of the diamond while it is still attached to the support shank is very easy.

Figure 3 [not reproduced] shows two motion picture frames in the bonding process when brazing of diamond and copper-tungsten alloy is performed using combustion synthesis. Frame (A) is immediately before the combustion reaction, and frame (B) immediately after. The diamond, alloy, and brazing material are arranged as shown in Figure 2. When a current is passed through a carbon ribbon heater directly that is in contact with the upper surface of the heat source pellet as shown in (A),

Fig. 4. Temperature Profiles in Instantaneous Bonding Process



Key: 1. Heat source pellet temperature (°C); 2. Time (sec); 3. Alloy & diamond temperatures (°C); 4. Heat source pellet; 5. Copper-tungsten alloy; 6. Diamond.

the heater glows orange-white. Its reflection can be seen on the surface of the alloy. As shown in (B), immediately after the combustion reaction the heater has turned black because the current no longer flows, the alloy and diamond have turned orange-white from conduction of the reaction heat, and the heat source pellet, whose heat is being captured, glows orange.

Figure 4 shows the alloy and diamond temperature profiles that accompany the combustion reaction of the heat source pellet. Because the generated heat is consumed in the temperature increases of the alloy and diamond, the maximum combustion temperature of the pellet peaks at 2700°C (read by two-color pyrometer), and in about 10 seconds it cools down to below 1000°C. On the other hand, the maximum temperature increases of the alloy and diamond (on its top surface) are about 1100°C and 800°C respectively (read by thermocouple), and we find that the diamond cools down at about 500°C/minute. There are no cracks in the alloy-diamond interface, and the two are bonded strongly together. For example, the shear fracture strength of the bonded surfaces of diamond and high speed steel, which has a thermal expansion coefficient three times greater than diamond, is about 370 MPa. It appears that this kind of instantaneous bonding is based on the following mechanism. The brazing material, which is originally a eutectic compound, is melted by the heat from the combustion reaction, and after reacting with the diamond and metal interfaces respectively, it becomes a supercooled liquid as a result of rapid cooling. The residual stress at the bonding interfaces is held to a minimum because the metal base has already contracted to a certain extent at the temperature at which the layer of brazing material solidifies.

Actually, we made the prototype single-edged cutting tool shown in Figure 5 [not reproduced] using this diamond-metal bonding method. We performed endurance testing on the diamond-alloy bonded portion by

machining an Al-Si alloy. Results confirm that this prototype has at least the same level of performance as previous products.

#### 4. Conclusion

Attempts have just begun to make practical use of bonding of unlike materials. These attempts are typified by using combustion synthesis for making ceramic-metal bonds, and this field is still at the research stage. However, because of its convenience, this new bonding method has plenty of

potential to lead directly to practical uses. More specifically, in the future we can expect development of bonding systems that have been considered impossible with past methods. They can be used in situations where it is difficult to supply heat to the entirety of the bodies to be bonded; for example, when we wish to bond only a portion of a very large sample, when we require high temperatures approaching 3000°C at the bonding site, and when we do not want to subject the bodies to be bonded to a high-temperature atmosphere for a long period of time.

**Hino Motors Develops Highly-Efficient Diesel Engine Using Iron-Piston**

43070107A Tokyo THE NIKKEI WEEKLY in English  
30 May 94 p 12

[Text] Using a unique piston material and a highly redesigned turbocharger, Hino Motors Ltd. has developed a practical, large diesel engine that operates with the best fuel efficiency ever reported.

Called the P11C, the new 10,000cc diesel engine has a combustion efficiency of 46 percent, compared to the maximum efficiency of 43 percent recorded with conventional diesel engines.

Combustion efficiency is directly related to fuel consumption, and an increase in combustion efficiency boosts fuel efficiency without sacrificing output or torque. Hino says the P11C can boost fuel efficiency by 10 percent. This translates not only into cost savings on fuel, but also a reduction in exhaust emissions.

The piston is fabricated from high-strength cast iron containing graphite, which Hino says has never been done before. This material is a much better thermal insulator than the aluminum metal alloys used in most diesel engine pistons, and as a result there is less heat lost from the combustion chamber. Though cast iron is heavier than aluminum alloys, it is much stronger, so the piston can be made thinner. The result is that the P11C weighs the same as a conventional diesel engine.

Greater heat efficiency in the combustion chamber also means increased energy from exhaust gases. Thus, a new turbocharger was designed to make use of this extra energy. In a turbocharger, the pressure of the exhaust gas rotates a turbine to supply more air to the combustion chamber.

Normally, the exhaust gas is aimed perpendicular to the turbine blades, but Hino designed a more efficient turbine, where the shape of the blades is modified such that the exhaust is aimed obliquely onto the rear of the blades.

The P11C is a practical engine, but at 10,000cc it can only be used by a certain class of trucks. Hino plans to continue with basic research on piston designs and to eventually develop similar engines for larger 13,000-17,000cc trucks, and for midsize trucks of up to 10,000cc.

**AIST To Develop EV With Methanol Fuel Cells**

43070108A Tokyo THE NIKKEI WEEKLY in English  
9 May 94 p 6

[Text] The Agency of Industrial Science and Technology will start development of electric vehicles driven by small fuel-cells using methanol as fuel, an agency official said.

The new vehicles neither require recharging nor emit air pollutants. The agency affiliated to the Ministry of

International Trade and Industry aims to commercialize trucks and buses equipped with improved fuel-cells over the next four years beginning with this fiscal year.

Recharging, which takes time and requires a large number of recharging stations nationwide, has been the main obstacle to popularizing electric cars. The new vehicle overcomes this barrier by replenishing its fuel.

Fuel-cells generate electricity at a high efficiency rate of 40-60 percent and emit virtually no air pollutants, including nitrogen oxide and carbon dioxide.

Meanwhile, Nissan Motor Co. has developed a fuel-efficient lean burn engine, officials announced at the end of last month.

According to a Ministry of Transport evaluation, the 1,500cc-type engine for Nissan's subcompact passenger car Sunny is 5 percent more efficient than ordinary engines, company officials said.

Despite lagging other automakers in the development of lean burn engines, Nissan managed to keep costs lower than other companies by sharing common parts with existing engines, officials said.

The newly developed lean burn engine had almost no decline in power compared with ordinary engines, the company said.

Nissan hopes to start selling Sunnys carrying the new engines from May, officials said. Initially Nissan plans to restrict the new engine to several hundred units which will retail at ¥30,000 (\$290) more than the existing Sunny.

Depending on the users' reaction, Nissan plans to expand the use of the engine to other models, including those in the 1,800cc class.

**Nippon Ecology Work System Corp. Develops Eco-Friendly CNG-Diesel Dual-Fuel Device**

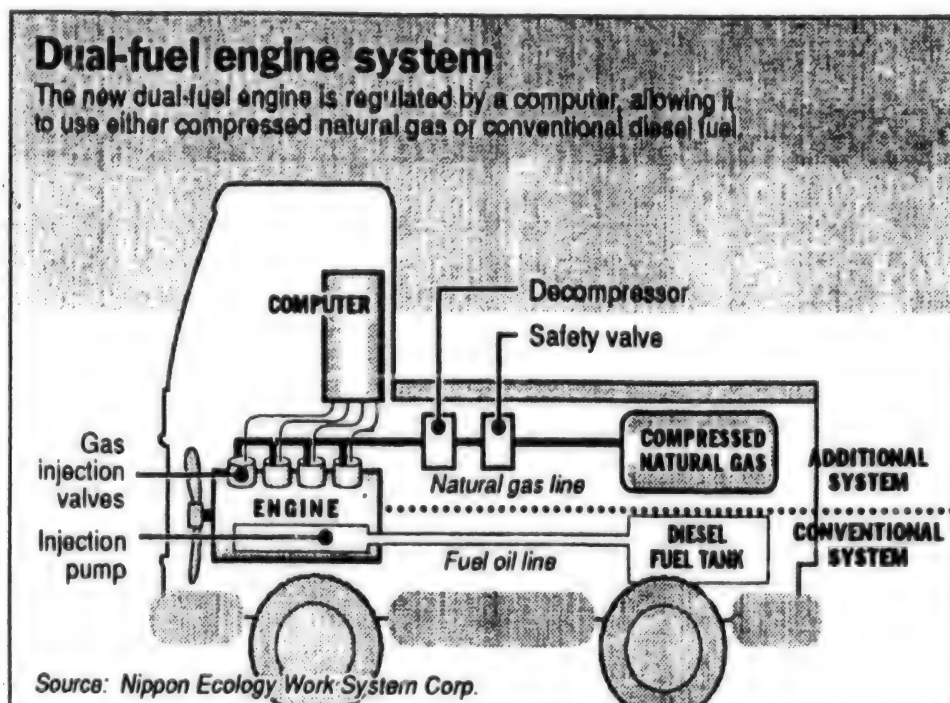
43070109A Tokyo THE NIKKEI WEEKLY in English  
9 May 94 p 6

[Text] The diesel trucks that cram Japan's roads may be contributing to the economy, but they are also wreaking havoc with the atmosphere.

Truck makers, under pressure to develop lower-polluting vehicles, are considering various design alternatives, including the use of cleaner-burning compressed natural gas (CNG).

The problem with CNG is that it needs a spark to be ignited for combustion, so there is no simple way to modify diesel engines—which do not use spark plugs—to run on pure CNG. That means there is no cheap way to turn the existing fleet of diesel trucks into low-polluting vehicles burning CNG.

At least not until now, that is. By using the spontaneous combustion characteristics of diesel fuel to provide the



spark to CNG, Nippon Ecology Work System Corp. has developed what it calls a CNG-diesel dual-fuel device that can be fitted to existing diesel engines and turn a diesel truck into a lower polluting vehicle for an investment of no more than ¥ 500,000 (\$4,800).

The dual-fuel device sends a mixture of air and CNG into the cylinder on the intake stroke. Diesel oil is injected on the compression stroke, just as in a conventional diesel engine, to ignite and provide the needed spark.

Although the truck still burns diesel oil, CNG is the primary fuel used. The result is that a diesel truck fitted with the dual-fuel device emits 20-30 percent less nitrous oxides and almost none of the black smoke, sulfur oxides and other pollutants emitted by a normal diesel truck.

Nippon Ecology Work System is an engine development venture company whose main backer is I.P.D., an Osaka manufacturer of environmental-protection devices. Other firms with capital in the venture include leading contractor Obayashi Corp. and Sanyo Electric Co.

The company is testing the prototype device on a standard diesel truck and plans to apply soon to the Ministry of Transport for permission to operate the truck on public roads.

The hybrid technology lends itself readily to commercialization due to the relatively low cost of installation, according to Takuro Miyazaki, director of the Environment Agency's Automobile Pollution Control Division.

Combined with emission-control technology now under development at leading truck makers, the dual-fuel devices could play a major role in improving air quality in urban centers, the Environment Agency believes.

**National Research Institute of Brewing Produces Chymosin Using Biotechnology**

43070102A Tokyo JAPAN CHEMICAL WEEK  
in English 19 May 94 p 5

[Text] Researchers at National Research Institute of Brewing, etc. have produced—with high efficiency—chymosin (milk-clotting enzyme) using bioengineered *Aspergillus oryzae*. Chimosin [as published] has been in short supply since it is usually obtained only from the bovine stomach. The original microorganism employed has been widely used in Japan's fermentation business and, the researchers claim, the recombinant enzyme offers high level safety in use on a commercial basis.

**NIBH, Tonen Mutate Bacteria to Survive in Petroleum**

94FE0609A Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 6 Apr 94 p 5

[Text] In a joint effort between the Bioengineering Industrial Technology Laboratory of the Agency of Industrial Science and Technology (AIST) and Tonen, a research group has succeeded in mutating bacteria that could only survive in aqueous solutions into bacteria that can live in organic solvents such as petroleum. By first exposing the bacteria to ultraviolet light and then adding an organic solvent, they were able to cause spontaneous mutations in three out of 400 million bacteria in the experiment, creating bacteria that can survive in organic solvents. The ability of these bacteria to survive in organic solvents makes it possible to overcome the previous restriction that microorganisms could only be exploited in aqueous solutions, thus opening the way to improved efficiency in various industrial processes. The joint research group says that this same method can be applied to other microorganisms, and real applications may begin soon.

The newly developed technology is one example of "time machine biotechnology", which refers to technology for causing deoxyribonucleic acid (DNA), the molecule that carries genetic information, to evolve at an artificially accelerated pace. Rather than just causing mutations at random, however, this technology chooses a desired function and tries to aim the mutation in that direction. Mutated organisms are produced by exposing cells or microorganisms to ultraviolet light to cause spontaneous mutations in a special environment.

In order to create bacteria that could survive in organic solvents, the joint team started with bacteria that could break down the sulfur compound named dibenzothiophene (DBT). The bacteria were first raised in a glass dish and exposed to ultraviolet light for 20 seconds. Then they were grown in a solution containing the organic solvent heptanol. The process was repeated 20 times with the concentration of heptanol slowly being increased.

Heptanol is a strong poison in which bacteria would normally die out completely. However, of the 400 million bacteria raised in the experiment, three were able to

survive in the organic solvent, and they even survived when the concentration of heptanol was 100%. The details of the spontaneous mutation are not known, but it seems that saturated fatty acids within the bacteria were changed into unsaturated fatty acids, and that was the reason for the tolerance of organic solvents.

The ability of the bacteria to break down DBT after the mutation was 80% of their ability to do that before the mutation. The joint team says that this is a general methodology that can be applied to many microorganisms used in chemical production processes.

**ETL Develops Technology to Observe Biomaterials by STM**

94FE0609B Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 18 Mar 94 p 4

[Text] The Electrotechnical Lab (ETL) of the Agency of Industrial Science and Technology (AIST) has developed a technology for observing biomaterials such as proteins in a stable form by means of scanning tunneling microscopy (STM). In STM, the condition of the surface of the substrate upon which the biological sample is placed is very important, so the research group developed a method of producing a gold substrate that was flat and clean down to the electronic level, and thus was able to clearly observe photosynthetic proteins with a size of several nanometers (1 nanometer = one-billionth of a meter). Applications are expected in a wide range of fields, such as in the technologies that are indispensable for analyzing various proteins and in the development of pharmaceuticals.

This research was sponsored by the Functional Protein Complex Applied Engineering Project of the Ministry of International Trade and Industry (MITI). The gold substrate was created by using independently improved vapor deposition equipment to deposit the gold on a mica substrate under an ultra-high vacuum. The point was to control the equipment temperature and speed of vapor deposition very accurately in order to produce the best results.

Under STM it was obvious that the substrate had a large, flat surface that was extremely clean. It was also found that the crystal structure of the gold atoms at the surface could be used to make the protein intended for study adhere to specific places.

To verify the new capability, a thin film of a protein that plays a central role in photosynthesis was made to adhere to the substrate by using the Langmuir-Blodgett (LB) technique, and STM observations were made. The result was that they could observe proteins with a size of several nanometers without the STM probe tearing the protein off the substrate. The research group says that the same kind of STM observations can be done with other proteins.

To make the method more convenient, they also developed a system that combines STM equipment with an

"inverted optical microscope" that is used in many fields such as electrophysiology. With this it is possible to choose viewing sites on the sample in units of millimeters, and then easily zoom in to the molecular level.

Although the use of STM is increasing in biology and chemistry, there are still many technical problems to be solved, especially with regard to the substrate.

In the past, most substrates used for STM had been made from graphite, but now we know that STM often showed the structure of the graphite itself, even when there was no protein or other material upon it. So it is necessary to reevaluate the previous STM results in fields such as genetics that were among the early users of STM.

### RIKEN Reads Plants' Genetic Code for Stress

94FE0609C Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 24 Mar 94 p 5

[Text] Immobile plants feel "stress" when exposed to unfavorable environments such as dryness or cold, and respond accordingly. The Life Science Tsukuba Center (manager Nobutaka Takahashi) of the Institute of Physical and Chemical Research (RIKEN), in cooperation with the International Agriculture, Forestry, and Fisheries Industrial Research Center of the Ministry of Agriculture and Forestry, has discovered two new control factors, appearing at the genetic level, that participate in the plant's reaction to stress. One of these factors is a control gene (control area = cis-factor) that appears when plants that have been exposed to dryness or cold respond to their environment at the genetic level. The other is a transcription control factor that acts through the hormone system to activate genes that respond to the environment. The same research group also says that the discovery of these two factors makes it possible to clarify the response functions at the molecular level for plants that have been exposed to the unfavorable environments of dryness and cold. If those functions are understood, it may be possible to grow crops freely in desert or cold areas, helping to solve the future food problems of the world.

This research is one result of the "Basic Technological Research for the Development of New Experimental Plant Systems" project that was made possible by "promotion and regulation funds" from the Science and Technology Agency (STA). The experiments use *Arabidopsis* (mustard family) as a model plant, extract substances that change at the genetic or protein level when such plants are exposed to dryness or cold, and use those substances to search for genes. As a result, twenty-five types of genes have been discovered that are related to dryness or cold, and they have been used to analyze the corresponding plant functions.

Plants secrete the plant hormone named abscisic acid when exposed to stress. This hormone affects two information pathways, one to activate genes related to stress, and one that involves genes that directly respond to the environment.

One of the discoveries in this latest series of experiments performed by this research group is a signal transmission pathway for genes that directly respond to the environment. This is a "control gene" composed of nine base pairs, named "DRE". The other discovery is a transcription control factor that works through the hormone system to control genes that respond to the environment. This plays an important role in the synthesis of proteins that respond to the environment.

The research results will be announced at the Japan Plant Physiology Society meeting that will be held at Tsukuba University, in Tsukuba city, Ibaraki prefecture, on 28 March.

### Gene Therapy Society To Be Established Next Spring

94FE0609D Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 24 Mar 94 p 6

[Text] The "Japan Gene Therapy Society" (tentative name) will be established in the spring of 1995 to further gene therapy in Japan, to bring together researchers in fields related to genetic diseases, AIDS, and cancer, and to foster the exchange of information about the latest research. The society is expected to be large from the beginning, comprising about 1,000 members, with the aim of publicizing and discussing the safety factors and therapeutic benefits of various new forms of equipment that are coming out of these research areas. An open forum for these discussions will be a great step forward in validating the safety of such equipment, as compared to the university ethics committees and other forums that are currently held behind closed doors.

At the present time, gene therapy for curing diseases by placing engineered genes inside the bodies of patients is carried on primarily in the United States, for life-threatening genetic diseases, incurable cancers, and AIDS. This form of therapy is about to begin in Japan as well, with the ethics committee of the medical department of Niigata University giving its approval for clinical applications. However, resources in Japan for this form of therapy are still inadequate, with the research said to be ten years behind that of America.

In particular, it is a problem that a system for checking the safety of the "vectors" (gene carriers) necessary for introducing genes does not exist. In America, the Recombinant DNA Advisory Committee (RAC) of the National Institutes of Health (NIH) holds public hearings on the safety and therapeutic value of gene therapy.

The researchers who are founding the new "gene society" hope it will play a role similar to that of the RAC.

### Fuji Photo Film Co. Discovers Bacteria that Decomposes EDTA

94FE0609E Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 4 Mar 94 p 5

[Text] Fuji Photo Film, in cooperation with Professor Katsumi Imada of the agriculture department of the

Tokyo Agricultural College, has discovered bacteria that can decompose ethylene diamine tetraacetate (EDTA), a substance that is of interest because it combines with heavy metals to pollute the environment. They took bacteria from soil and grew repeated generations of them until the ability to decompose EDTA had risen to essentially 100%. If such bacteria were used to make a bioreactor, it would be possible to process EDTA at low cost. EDTA is widely used in photographic and cleaning processes, but is increasingly coming under strict regulation, especially in Europe.

EDTA combines with metals to form compounds known as chelates that have a wide range of uses. For instance, they are used as additives for improving the sudsing ability of cleansers by removing metals from hard water, and they are also used as bleaching agents in photographic processes and as stabilizing agents in cosmetics. EDTA itself is not poisonous. However, when released to the environment, it is slow to decompose and therefore remains in existence for a long time, and after combining with silver or cadmium in the ground it can cause great harm to organisms. There have been reports of as much as three tons being dumped into the Rhine per day, and regulations concerning the amounts that can be present in manufactured goods or in wastes are becoming increasingly strict in European countries such as Germany and Austria, as well as in the United States.

Fuji Photo Film and Tokyo Agricultural College Professor Imada sampled the soil from the western part of Kanagawa prefecture and confirmed that two types of bacteria, bacilli and pseudomonads, had a good capability for decomposing EDTA. They grew repeated generations of these natural bacteria to increase their activity until, upon giving them an iron-EDTA solution of the same concentration as actual waste, the bacteria were able to decompose essentially 100% of it in two weeks.

EDTA may also be processed by photolysis or ozone oxidation, but the high cost makes it impractical for industrial application. For this reason, foreign chemical companies are said to be developing alternative compounds to EDTA. Japan does not yet regulate EDTA, but Fuji is thinking of the future. They envision systems that place these bacteria into a column, allow waste that contains EDTA to enter at the top, and decompose the EDTA by a continuous process.

#### **Mitsubishi Chemical Industries To Develop Biopharmaceuticals with U.S. Company**

94FE069F Tokyo *NIHON KEIZAI SHIMBUN*  
in Japanese 6 Mar 94 p 5

[Text] On 4 March, Mitsubishi Chemical Industries and the American biotechnology company IDEC Pharmaceuticals announced that they had reached agreement on joint development and marketing of medicines to suppress the immune reaction after organ transplant surgery and medicines to treat autoimmune diseases. Mitsubishi

Chemical Industries will cooperate with IDEC in order to strengthen its development and marketing of biopharmaceuticals that are created through gene recombination technology.

Mitsubishi will provide the capital necessary for development of the pharmaceuticals, and IDEC will provide the anti-B7 antigen that is a candidate for uses such as immune suppression. If commercialization is successful, Mitsubishi Chemical Industries will obtain the marketing rights for a certain territory including Japan, and will pay a fixed percentage of the sales to IDEC for use of the patent.

The anti-B7 antigen is a combination of simian and human antigen components, and is expected to be able to control undesired immune reactions in the body and to help combat autoimmune diseases. IDEC has already established a mass production system for supplying the anti-B7 antigen at low cost. Tests have only been done in vitro at present, but they hope to begin clinical testing as early as the end of 1995.

Mitsubishi Chemical Industries is a Japanese pharmaceutical company that is engaged in developing and marketing biopharmaceuticals. They are currently selling a medicine to dissolve blood clots and a hepatitis-B vaccine that were created through gene recombination.

#### **Kaken Pharmaceutical Co. To Invest in US Biotechnology Venture Business**

94FE0609G Tokyo *NIKKEI SANGYO SHIMBUN*  
in Japanese 9 Feb 94 p 1

[Text] Kaken Pharmaceutical, a relatively large drug manufacturer, is embarking on serious investments in the American biotechnology venture business. Starting with the 1994 fiscal year they will be providing financial backing and research assistance to several companies in order to help them begin pharmaceutical research. Negotiations have already begun with several companies. In America, the Clinton administration's medical insurance federal cutbacks have created a poor economic climate for biotechnology related venture businesses, VB's and so Kaken is responding to the call from America for more investment from Japan.

Kaken's investment plans include:

- (1) purchasing VB stock,
- (2) providing money to aid research,
- (3) paying early royalties for products under research.

They plan to keep the amount invested in any one company under ¥100 million. With these investments, Kaken intends to have a strong voice in choosing the pharmaceuticals to be developed by American business.

The studies are being undertaken by Kaken USA, a wholly owned subsidiary of Kaken. At present, Kaken is conducting negotiations with VB's in the area of plastic

pharmaceuticals, in which Kaken has a strong marketing position. They will continue to investigate one or two companies each year, planning to make investments over a number of years.

Kaken's sales of a medicine for treating joint ailments, developed and manufactured by Seikagaku Kogyo, are going well. However, right now they have a shortage of candidate pharmaceuticals for new clinical tests, so they are looking for capital investments to strengthen their product line. As the competition increases in developing new products, there is a growing trend among small, mid-size, and relatively large manufacturers to seek joint ownership of developed products both in Japan and abroad.

#### **JICST To Provide GDB for Genetic Map Information**

94FE0609H Tokyo NIHON KOGYO SHIMBUN  
in Japanese 18 Feb 94 p 1

[Text] Beginning 22 February, the Japan Information Center of Science and Technology (JICST, chairman Moritaka Nakamura) will put in place within Japan the international genetic map database (GDB).

GDB is a database set up at Johns Hopkins University in the United States. It contains a genetic map showing which genes are at which locations on which chromosomes, as well as other kinds of information such as references to the literature and information about genetic diseases. International cooperation is required to set up nodes in various countries to become part of this network, and Japan is the sixth one after England, Germany, Austria, Holland, and Sweden.

An experimental implementation has been in place at JICST since November of last year, but now with preparations complete the equipment will be moved to JICST's GDB center in Tsukuba City, Ibaraki Prefecture, for the real implementation.

The Japanese research information network also allows one to receive information at any time, for free, using telephone lines or ISDN (integrated services digital network).

#### **Mitsubishi Chemical Industries Develops Basic Technology Applicable to Cell Reactor**

94FE0609I Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 3 Feb 94 p 5

[Text] Mitsubishi Chemical Industries has developed the basic technology necessary for the next generation of production system "micro-cell reactors" that will create useful substances by imitating the workings of biological cells. They have clarified the major relationships between the structure and function of the protein known as the glutamic acid receptor, which serves as an important information pathway for controlling intracellular biochemical reactions. They have also used recombinant

gene technology to develop mass production capabilities, and have entered the commercialization stage. Besides applying this to the cellular biochemical reaction control system, they also expect their work to be helpful in explaining higher brain functions such as memory and learning.

The glutamic acid receptor is composed of several proteins named  $\alpha 1$  and  $\alpha 2$ . The receptor has two functions: to capture glutamic acid molecules, and to open the calcium ion channels in cell membranes. Opening the channels causes the intracellular concentration of calcium ions to change, causing changes in the functions of various cell components.

Thus, it is possible to use glutamic acid as an extracellular signal to control the reactions of substances such as enzyme proteins within micro-cell reactors, which resemble biological cells.

The research group at Mitsubishi Chemical Industries used the methods of genetic engineering to cause mutations in various parts of the glutamic acid receptor in mice, to investigate the functions of those parts. Thus, they determined the crucial portion (amino acid sequence) of the  $\alpha 1$  protein which is responsible for glutamic acid selectivity. With regard to the  $\alpha 2$  protein, which is responsible for the calcium ion channel function, they also discovered the amino acid sequence that controls ion permeability.

If this information can be used with the techniques of genetic engineering to improve the glutamic acid receptor, it may be possible to control selectivity for other substances besides glutamic acid, or to regulate the permeability of the calcium ion channel.

The research group also combined the  $\alpha 1$  and  $\alpha 2$  genes with an insect virus and introduced them into a type of mosquito, in order to develop mass production technology.

Mitsubishi Chemical Industries is also proceeding with the mass production synthesis of phosphatidyl ethanolamine modified lipid, an artificial cell membrane in which mass produced receptors may be imbedded, and in the future hopes to artificially reproduce the glutamic acid receptor function by combining the receptor with lipid.

The present research is sponsored by the "Functional Protein Complex Applied Technology" project of the Ministry of International Trade and Industry (MITI), a joint effort of government and industry to produce cell reactors.

#### **Pharmaceutical Companies To Establish "Aging Gene" Research Institute**

94FE0609J Tokyo NIHON KEIZAI SHIMBUN  
in Japanese 5 Mar 94 p 10

[Text] On 17 March, four pharmaceutical companies in conjunction with the Foundation For Research Into

Cures For Drug Side Effects will establish the "Aging Research Laboratory" to study the riddle of aging at the genetic level. Many genes related to aging have recently been discovered, but the aim is to study their function in more detail so as to clarify the aging mechanism in order to develop medicines for diseases such as cancer and bone disease that afflict many older persons. Eighty-six million yen will be invested the first year, and the project will run for seven years.

The four participating companies are Nihon Rosh, Eisai, Kissei Pharmaceuticals, and Meiji Seika. The foundation and the companies will provide funds in the ratio of 7:3, and the laboratory will be established within Nihon Rosh Laboratories in Kamakura City.

Recent research indicates that multiple genes are involved with the speed of the aging process. The Aging Research Laboratory will look for these genes and study their functions.

Among these, the chromosome location is fairly well narrowed down for the gene that causes Werner's syndrome, a disease in which one begins aging in one's thirties, the arteries harden, and cancer becomes more likely. Thus, this gene should soon be identified. After finding a gene, the next step is to analyze the corresponding protein to understand how it participates in the aging process. Also, in order to understand aging at the cellular level, the laboratory will also study cell reproduction control genes that function well in old cells.

There are many diseases which appear in old age, such as cancer, arteriosclerosis, bone disease, and cataracts. Research into the genes that cause aging should clarify the mechanisms by which these diseases appear.

#### **NISES To Develop Transgenic Plants**

94FE0609K Tokyo NIHON KOGYO SHIMBUN  
in Japanese 18 Feb 94 p 7

[Text] The Silkworm and Insect Agriculture Engineering Laboratory (chairman Kiyoshi Kawakami) of the Ministry of Agriculture, Forestry, and Fisheries has discovered that an anti-bacterial agent produced by insects is very effective at controlling the reproduction of bacteria that cause disease in plants. The Silkworm and Insect Laboratory is hopeful that resistance to disease can be conferred by incorporating the gene for this protein into plants. Experiments have shown a strong ability to kill eight representative types of bacteria that cause diseases in plants. The laboratory next plans to produce transgenic plants that actually contain the gene for this protein. This research is being carried out by a research group led by Minoru Yamakawa of the Biological Defense Mechanisms Laboratory within the Biological Information Department of the Silkworm and Insect Laboratory.

All organisms are equipped with defense mechanisms for fighting off invasions by foreign substances such as

bacteria. Vertebrates, including man, make use of interactions between antibodies and antigens, but insects use other methods, such as producing proteins that kill invading bacteria.

The anti-bacterial protein used in the experiments is "secropin-B", which is produced by most insects. It is a chain of 38 amino acids with a molecular weight of 2000.

This protein is the strongest of the anti-bacterial proteins and works against a large variety of bacteria. It is hard to obtain it in quantity because insects only produce it in extremely minute amounts, so the experiments used secropin-B that had been artificially produced with peptide synthesis equipment.

The ability to control the reproduction of ten representative types of disease causing bacteria known as "rice white leaf wilting" bacteria, "tomato ulcer" bacteria, and "barley black joint" bacteria was investigated. With the exception of "rick husk wilting" bacteria and some varieties of "wilting bacteria", a remarkable ability to control reproduction was found for eight of these varieties of bacteria.

Mr. Yamakawa's group next plans to obtain the secropin-B gene from silkworms or other insects and incorporate it into plants to evaluate its effectiveness. Since the mechanisms by which secropin-B finds its bacterial targets are similar to those used by the anti-bacterial proteins created by a plant's own genes, the group believes that its transgenic plants will be successful.

#### **MHI Develops Bioreactor for High Density Culture**

94FE0609L Tokyo NIHON KOGYO SHIMBUN  
in Japanese 24 Feb 94 p 7

[Text] Mitsubishi Heavy Industries (president Kentaro Aikawa) has developed a bioreactor that can grow photosynthetic algae with a density ten times greater than their previous equipment.

The previous limit for microscopic algae was one gram per liter, but now they are able to grow up to 12 grams per liter. In the future, they plan to develop and operate reactors whose capacities will be measured in tons.

High density cultivation has been achieved for the first time by using optical fibers to cause photosynthesis and attaching special anti-adhesive material to the fibers to prevent them from adhering to the algae. This avoids the production of coagulating agents that prevent growth, and the algae can be grown at the desired, consistent separation distance. The introduction of carbon dioxide through a hollow fiber membrane keeps out bacteria, making it possible to have a pure, large-scale cultivation system.

The new reactor has the optical fiber light source at the center. Algae, bacteria, or seeds are placed into it, carbon

dioxide is introduced, and photosynthesis is caused in the culture using a 500 lux metal halide lamp as the light source.

Repeated tests at the company's Takasago (Hyogo Prefecture) Laboratories have shown that after 26 days of illumination a mass of 24 grams is produced per 2 liters. In the past it was possible to produce 1 gram in a week, but after that bacteria developed so that large-scale cultivation was difficult.

#### **Chugai Pharmaceutical Co. to Reinforce Domestic R&D**

94FE0477A Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 25 Feb 94 p 22

[Text]

#### **Introduction**

Chugai Pharmaceutical Co. will strengthen its research and development structure in Japan with an investment of ¥10 billion. They will expand the research facility in Gotemba, Shizuoka Prefecture, while providing the Ukima plant in Kita-ku, Tokyo, with a research capability for drug preparation focussing on new drugs such as biotechnological preparations. They expect to begin both of these projects in 1994. As a result of the emphasis placed on research and development, the number of key staff in development increased rapidly making it difficult to work in the existing facility. In addition, an increased number of collaborative research proposals involving overseas firms has heightened the need to renovate the domestic research and development structure.

At the Fuji-Gotemba Research Institute, they will expand the investigative research wings for creating chemical products for pharmaceuticals at about ¥3 billion. The number of R&D staff has now increased to approximately 600, and the existing research wings have become crowded. Chugai is advancing collaborative research with an Australian pharmaceutical concern, Amrad Corp. and a Korean pharmaceutical research facility, C & C. In the future, they would like to set up a centralized control function for worldwide R&D information at the Fuji-Gotemba Research Institute.

The Ukima Plant is currently manufacturing preparations such as an anticancer agent, "Picibanil [phonetic]" (trade name), an analgesic therapeutic, "Sigmart [phonetic]" (trade name), and products developed for clinical trials. These preparations are exchanged sequentially for new drugs. A likely target is a contrast medium for angiography, "Imagenil [phonetic]" (trade name), which is pending for manufacturing approval by the Ministry of Health and Welfare; transfer of the product is expected to take several years. Regarding the pharmaceuticals to be developed in the future in pace with changes in manufacturing products, they expect to develop drugs with high efficacies and safety and

strengthen research functions such as high efficiency production technologies. In addition, they will establish a new wing for solid preparations to manufacture tablets, etc. within the Utsunomiya Plant in Tochigi Prefecture.

Chugai plans to invest ¥10 billion in FY94, twice the amount of the previous fiscal year investment, for improvement of the Fuji-Gotemba Research Laboratories, Utsunomiya Plant, Ukima Plant, etc. For the past several years, many corporations in Japan and abroad in the pharmaceuticals industry, have announced improvement of their R&D structures. Chugai Pharmaceutical will begin reviewing their facilities in order to respond to these trends.

#### **Tokyo Electric Power Co. Discovers Microalgae with CO<sub>2</sub> Absorption Higher than Tropical Rain Forest**

94FE0477B Tokyo DENKI SHIMBUN in Japanese  
25 Feb 94 p 1

[Text] Tokyo Electric Power Co. announced on the 24th that they discovered and successfully cultured microalgae which have an approximately 4-fold higher capacity than the tropical rain forest to absorb and fix, by photosynthesis, CO<sub>2</sub>, a main cause of global warming.

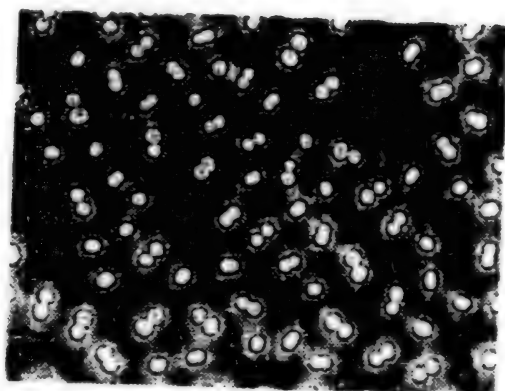
The microalgae are called "blue-green algae, synechocystis" inhabiting seawater. The CO<sub>2</sub> absorption capacity per day (photosynthesis rate) is approximately 30 grams (carbon conversion per 1 square meter) compared to approximately 7.6 grams (same conversion rate as above) of the tropical rain forest. Only one fourth by area of the tropical rain forest is required to fix the same amount of CO<sub>2</sub>.

Since the algae are also capable of absorbing nitrous and sulfurous acids, which were previously believed to be harmful to plants, as nutrients, the scientists contend that not only a CO<sub>2</sub> countermeasure, but also an anti-acid rain effect can be expected.

Currently, research organizations including those in government and universities are conducting CO<sub>2</sub> fixation research using photosynthesis of various plants as well as research on inorganic fixation by shell formation, etc. Tokyo Electric Power also established a biotechnology laboratory in 1990 and has been conducting research on biotechnological processing technology using photosynthesis of plants.

In this research, the key for success lies in the discovery of plants which are capable of efficient absorption of a large quantity of CO<sub>2</sub> and suitable for large-scale cultivation. A plant having a high CO<sub>2</sub> absorption capacity coupled with suitability for large-scale cultivation is economically advantageous because of the reduced area required in the treatment plant.

Tokyo Electric Power Co. focussed on the property of plants that the rate of photosynthesis increases as the



Key: 1. Microalgae "Blue-green algae, *Synechocystis*"

temperature increases. They decided to survey and collect microalgae inhabiting high-temperature hot springs, and numerous samples were gathered from several hot springs in Japan for analyses and evaluation.

The result revealed that the blue-green alga, *synechocystis*, collected from Jinata hot spring in Shikine Island of the Izushichito the most superior in absorption capacity.

The algae showed the highest rate of growth at a culture temperature of 45°C, with a cell division cycle of 4 hours. Since it grows in seawater, the large quantity of water required in a large-scale culture is manageable with seawater.

Even when these microalgae are used, approximately 40 square kilometers, about 8.6 times the area of the Tokyo Dome [a 50,000-person capacity baseball stadium], is required in order to absorb and fix CO<sub>2</sub> exhausted by one unit of a 600,000-kilowatt class LNG [liquefied natural gas] thermal power plant.

Based on these facts, Tokyo Electric Power now plans to collect and culture new microalgae having a high absorption capacity at room temperature, systematize microalga culture methodology and improve culture technology.

#### Japanese Professional School Establishes Biotech Exchange Program with U.S. College

94FE0477C Tokyo RYUTSU SABISU SHIMBUN  
in Japanese 25 Feb 94 p 16

[Text]

#### Introduction

The Osaka School of High Technology (1-2-43, K. Uki-fune, director) will establish a one-year overseas study program at a U.S. junior college, Contra Costa College (CCC, San Pablo, CA) to train international basic research technicians in biotechnology. They are scheduled to formally sign an agreement in mid-March and

implement the program in August. The above program includes hands-on training in U.S. biotech firms, a first for such training in Japanese vocational schools. Osaka High-Tech plans to expand the curriculum in the program, while taking one exchange student a year from CCC through an established scholarship system.

CCC is a state junior college with an enrollment of 10,000 students. Courses offered include biotechnology, computer science, materials science, health science, etc. Many of the courses offered are common to Osaka High-Tech, which led to the recent plan to establish the exchange program.

The place of overseas study is CCC's High Technology Department. Two to four students will be chosen each year from the second-year class of the Osaka High-Tech's Life Engineering Technology Department. The curriculum will include besides English, organic chemistry and biochemistry, general biotechnology, general biology, computer concepts, etc.

In addition, one-month hands-on training at companies precedes and follows the course work. This training will take place at ten venture firms for biotechnology research in the State of California including Genetics, Inc. and Baxter Healthcare. These ten companies provided funds for establishing the High Technology Department. The substance of training is mainly basic science such as recombinant DNA and tissue biotechnology.

Osaka High-Tech stated that "the training at biotechnology firms is a valuable experience which is not available in Japan. One can learn English as well and the courses taken should be beneficial in finding work as basic technicians." In the future, they will expand the exchange program to include areas other than biotechnology, including materials science and information processing.

#### NIBH, Hisamitsu Pharmaceutical Co. Jointly Develop Carrier for Genetic Medicine

94FE0477D Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 24 Feb 94 p 4

[Text]

#### Introduction

[Tsukuba] The National Institute of Bioscience and Human Technology, Agency of Industrial Science and Technology and Hisamitsu Pharmaceutical Co. jointly developed a carrier technology for stable delivery into the body of so-called genetic drugs, which arrest intractable diseases such as cancer and AIDS at the genetic level. It is a technique to encapsulate with polyamino acids. Studies are being advanced on therapeutics consisting of genetic drugs such as antisense DNA and ribozyme. However, since they are readily degraded *in vivo* by enzymes, it has been thought difficult to use these substances as drugs. The new technology may overcome this problem.

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The substance developed is a polyamino acid called poly-L-lysine-serine polymer (PLS). It forms a conjugate by bonding with a genetic drug and protects the drug from degradation enzymes *in vivo*. It is stable in the bloodstream, but in an acidic environment below pH 6.5, it virtually completely releases the genetic drug. When entering a target cell, it pass through the acidic portion of the cell membrane, and the drug is efficiently delivered inside. It accomplishes roles of both protector and carrier.

The research group confirmed that the new carrier-genetic drug conjugate was stable for over 24 hours in human serum. Later, they will confirm its efficacy with experimental animals such as mice. Since the carrier itself can be synthesized easily by using existing technology, the cost can be held low as well.

It has been known that polyamino acids can protect genetic drugs, but they either coagulated readily or were toxic making them unfit as a drug carrier. The research group proved that amino acid-gene bonding is not by the previously-believed charged force, but by stereostructural force. They increased stereostructures which enhance gene support and succeeded in developing a high performance carrier.

Antisense DNA covers a gene (DNA) that cause disease in order to treat the disease, and ribozyme acts to cut and remove the pathogenic gene. Both of these substances are called genetic drugs, and expectations are upon them as new technology drugs to radically arrest disease onset. Because they act on the target gene alone, there are few side effects, and efficacy is high.

However, since they are readily degraded *in vivo*, the U.S. and other countries are advancing research for their practical application even by directly incorporating them *in vivo* for gene therapy.

#### **Alpha Successfully Cultivates Effective Microorganisms Using Biotechnology**

94FE0477E Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 22 Feb 94 p 16

[Text]

#### **Introduction**

Using a unique proprietary biotechnology, a food-related appliance manufacturer, Alpha (Kagawa Prefecture) succeeded in growing a group of efficacious microorganisms for arresting bacterial growth even at a high temperature. When these microorganisms are used with a proprietary bacteriostatic agent, Biocon [phonetic], by converting them into an aerosol, spraying it over food and preserving the food at 0°C, the company obtained "favorable results in that common bacteria did not grow even after 12 days and Escherichia coli counts were reduced" (Oosumi, president). The company will soon request various tests by public [health] organizations for safety assurance.

Alpha in collaboration with H. Hayashi, a professor at Tsukuba University (formerly a professor at Kagawa Medical School) has developed a Biocon bacteriostatic action to prevent changes in the appearance and taste of food by arresting the growth of bacteria that cause putrefaction and deterioration. The company has been advancing research on technology for the additive-free preservation of fresh food using efficacious microorganisms.

The microorganism they have recently succeeded in growing is in a group of efficacious microorganisms in a species similar to yeast. Although efficacious microorganisms are weak at high temperatures, they were able to use them for a proprietary fermentation technology so that they tolerate high temperatures ranging 500-800°C.

The company uses these efficacious microorganisms in a mixture with Biocon bacteriostatic agent consisting of ammonium bicarbonate, carbon dioxide, table salt, and water as principal ingredients. This mixture is converted into a fine aerosol, sprayed over food, allowed to stand at 0°C and tested for bacterial growth. As a result, "common bacteria did not grow even after 12 days, and E. coli counts were reduced from the time when the tests began" (Oosumi, president). Furthermore, freshness was adequately maintained.

The company plans to "have it tested by a public [health] organization since it involves foodstuffs." When these microorganisms are confirmed to be safe for humans, the company expects that a great transformation will occur in the fresh foodstuffs, especially in the distribution process of fishes.

#### **MITI To Begin Raw Garbage Reduction Technology R&D Using Biotechnology**

94FE0477F Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 22 Feb 94 p 3

[Text] MITI will begin research and development of raw garbage reduction technology by applying biotechnology to suppress odors and enable high speed processing. They will construct a demonstration plant with a processing capacity of 1 ton per day by investing ¥350 million and will begin operation in mid-FY94. The plan aims to establish the processing technology over a period of 3 years. Concrete plans began with measures taken up by the third supplementary FY93 budget.

Currently, the reduction of raw garbage by the demonstration plant requires several months; they will establish a technology to shorten it to several weeks. In addition, they contend that the processed raw garbage can be used for landfill as well as for organic fertilizer.

In garbage processing, the large amount of water contained in raw garbage is the cause of odor. Consequently, they will strive to reduce the water content through biotechnology using natural microorganisms in the demonstration plant and aim for a processing technology that suppress odor production.

On the other hand, for high speed garbage processing, the plan is to shorten the reduction period, which is said to generally take several months, to several weeks. The research will proceed to develop a technology targeting a broad demand stratum such as regional autonomous bodies and large private food and beverage businesses.

#### **STAFF Conducts Genome Analysis Research Projects**

94FE0477G Tokyo KAGAKU KOGYO NIPPO  
in Japanese 21 Feb 94 p 11

[Text]

#### **Start-up With Three Projects**

The Agricultural, Forestry, and Fisheries Advanced Technology Institute, an affiliated institute of The Society for Techno-Innovation of Agriculture, Forestry, and Fisheries (STAFF), was completed in Tsukuba City in November of last year. Its mission is to conduct leading-edge research to serve as a base for future biotechnology in the field of agriculture. Research has already begun at the new facility on three projects (rice genome analysis, livestock genome analysis, symbiotic rumen microorganisms) jointly with research organizations affiliated with the Ministry of Agriculture, Forestry, and Fisheries (MAFF); it is apparently showing a smooth start-up.

The Institute is a five-story building with a total floor area of approximately 3,400 square meters. The layout for each level is designed in separate left and right wings. The impression of the laboratories at a glance is that few demarcations are present. In concurrence with the large-scale project, both offices and laboratories of the research staff are purposely designed to be one big room to facilitate elastic correspondence with the research progress and promote information exchange. A DNA sequencer laboratory where sequencers, computers, etc. are concentrated; information analysis laboratory; and freezer room were specially established to facilitate research efficiency. In addition, the provision for exclusive conference room in each research department has been taken into consideration to promote interchange and information exchange among researchers from both in Japan and abroad. The total number of research staff is 54 including people sent from STAFF member firms. They are divided in two research departments (M. Kobayashi, head of the First Research Department; S. Kawabata, head of the Second Research Department).

The First Research Department is assigned to rice genome analysis research. With the objective to develop new technology for the Japanese staple food, rice, they aim to determine the base sequences of rice chromosomes. Research itself started in December 1991 in an interchange/joint format with MAFF's National Institute of Agrobiological Resources. So far, they have mapped approximately 1,100 RFLP markers, and steady

achievements are also reported in substance map making for rice plants and determination of base sequences.

#### **Livestock-Related Achievements**

The Second Research Department established its research project on livestock. As with rice, searching for useful genes is the objective, and research on livestock genome analysis began in 1991 in collaboration with MAFF's National Institute of Animal Industry. They have reported specific achievements in the areas of anti-disease gene elucidation and technological development for determining solids. The results are being used in related research at both government and private organizations. In addition, starting last year, symbiotic rumen microorganisms were added to the research projects. It was commissioned by MAFF's National Institute of Animal Industry; they will look for useful microorganisms inhabiting rumens (ruminant stomach such as of a cow), analyses which are virtually unknown at the genetic level although they are known to possess diverse functions, analyze useful genes of rumen bacteria, and develop the functions of useful microorganisms.

The development of these research projects in the new laboratories will be watched with interest. Furthermore, the promotion of joint research with the private sector, e.g., STAFF member firms, may also be expected in the future.

#### **Oriental Yeast Co. To Begin Production of Gene-Recombinant Diagnostic Medicine**

94FE0477H Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 23 Feb 94 p 19

[Text] Oriental Yeast Co. Ltd. (Y. Honma, president) will begin production, in April, of a physiologically active substances using recombinant DNA technology. They will produce 17 items including human C-reactive protein (CRP) and offer them as raw materials for diagnostics and reagents. Once established, they will launch full-scale production as early as next autumn and aim for ¥300 million sales in the first fiscal year.

The company is supplying natural physiologically active substances as diagnostics and reagents to clinical trial kit manufacturers. Recombinant DNA technology can be used to produce these substances at a lower cost than the natural type. Seventeen items to be supplied using recombinant DNA technology include, in addition to CRP, human  $\beta_2$ microglobulin (BMG), phosphoglyceric [phonetic] acid mutase isozyme (PGAM), isocitrate dehydrogenase (iCD), etc. All of these substances will be supplied as recombinant DNA products made available by the company for the first time. Regarding CRP, the company succeeded in expressing it by recombinant DNA technology.

Production will be at the Nagahama plant in Shiga Prefecture. They will aim for sales of ¥300 million in the first fiscal year, ¥1 billion in the second year.

**Otsuka Pharmaceutical Co. To Develop Diagnostic Medicine, Food Based on Genome Analysis**

94FE04771 Tokyo NIKKEI BIOTECHNOLOGY  
in Japanese 17 Jan 94 p 2

[Text] It has been revealed that, in May 1993, Otsuka Pharmaceutical Co. inaugurated the Tokushima Research Institute in the company's Diagnostics Business Division and started human genome research targeting at the cloning of disease-related genes and body constitution-related genes. Due to rapid progress in human genome research, the commercialization of human genome research began in the United States last year. The start-ups of venture firms such as Millennium Pharmaceuticals of the United States, which develop drugs and diagnostics based on disease-related genes, are occurring rapidly (see 27 Sep 93 issue, p. B11). Many of the firms regard human genome research as basic research. An enlightened firm, which aims at the commercialization of human genome analyses, has finally appeared in Japan, as well.

"Among the 100,000 human genes, there ought to be some genes that are medically important. Based on these genes, our aim is to develop therapeutics and diagnostics. In the future, genetic information of body constitution, etc. will also become useful for the development of proprietary food products as well as progress in preventive medicine" (H. Maekawa, Chief, Diagnostics Business Division, Otsuka Pharmaceutical Co.).

The company is pursuing human genome research under the guidance of Y. Nakamura, chief, Department of Biochemistry, Cancer Institute of the Japanese Foundation for Cancer Research, who is a pioneer in Japanese clinical human genome research. The immediate goal is to clone cDNA related to diseases. Of the 43 research staff at Tokushima Research Institute, 15 were assigned to human genome research. The remainder of the staff are responsible for the development of diagnostics and devices. They installed eight DNA sequencers and set up a two-shift working structure for research staff to clone disease genes. They prepared a cDNA library from mRNA extracted from commercial fetal brain [tissues] and finished a partial sequence [of the cDNA]. Beginning this year, they will begin full sequencing of newly discovered genes. In addition, they plan to express new cDNA and initiate studies of its functions. [2 lines deleted]

"Knowledge from the clinical diagnostic laboratory including computers, data analysis system, automation of biochemical reactions, trained research staff, etc. were directly useful in the genome analysis research. Consequently, the cDNA analysis of the brain progressed faster than we expected" (Maekawa). The Institute of Genomic Research, which was established by G. Venter, one of the leaders of genome analysis in the United States, is also vigorously pursuing the analysis of brain cDNA.

Human genome analysis is no longer basic research that can be left to the government. As long as human genetic

analysis serves as the foundation for developing new services including development of drugs, diagnostics, preventive medicine, and foodstuffs which are necessary for an advancing aged society in the future, it is inevitable that they are left out of the promising market unless private firms also boldly challenge genome research.

**NIBH Develops Technology to Integrate Lipid Films**

94FE0477J Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 17 Jan 94 p 5

[Text]

**Introduction**

The National Institute of Bioscience and Human Technology, Agency of Industrial Science and Technology developed a technology for artificially fusing lipid membranes such as biomembranes together. A membrane fusion protein of influenza virus was embedded in a liposome and given the function of a "glue." The special feature is that the fusion function can be controlled by changing the ambient acidity. Research and development of a cell reactor for artificially reproducing efficient cellular production of substances are underway through collaborative efforts between the government and industry. The new technology will serve as its foundation. It is also promising as a drug delivery system (DDS).

The new technology uses hemagglutinin, a protein that protrudes like a thorn from the surface of influenza virus. It acts at the time of fusion with infecting cells and facilitates invasion of viral genes into the cell.

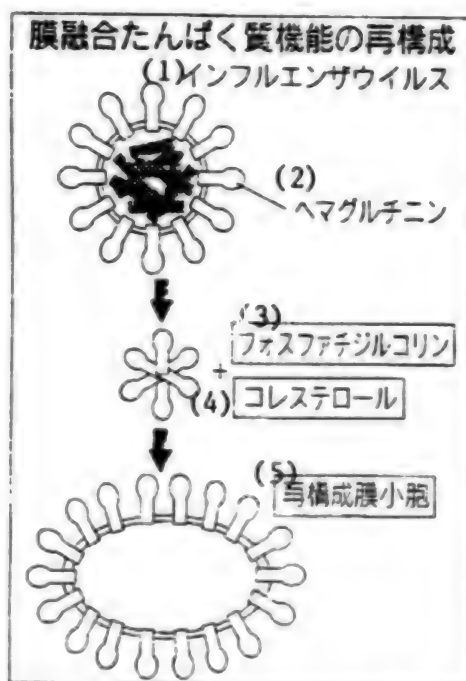
First, viral membrane is dissolved with a surfactant, and after the membrane composed of lipid and protein is broken up, the target protein is purified by a method called sucrose density-gradient centrifugation. Next, this protein is mixed with lipids, cholesterol and phosphatidylcholine, and a liposome with a diameter of several tenths of micron (1 micron is 1/1,000 millimeter) with hemagglutinin embedded on the surface is constructed.

In order to examine the function of membrane fusion, this liposome was mixed with human erythrocyte membranes. When the ambient acidity was neutral, membrane fusion did not occur, whereas in a weakly acidic milieu, fusion occurred and 70-80% of the liposomes functioned. This result provided the prospect for controlling membrane fusion.

The new technology will serve as the basis for a cell reactor, the new substance production system Japan is proposing. This system mimics the highly efficient substance production system present in cells. Unlike today's bioreactor which uses an enzyme, etc. by itself, it will operate like a cellular production system, from adding raw materials and energy, to removing the final product. They plan to use the above technology in a mechanism called exocytosis.

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Reconstruction of membrane fusion protein function



Key: 1. influenza virus; 2. hemagglutinin; 3. phosphatidylcholine; 4. cholesterol; 5. reconstructed vesicles.

In addition, a drug is placed inside the liposome and wrapped again with another lipid membrane, which serves as a capsule capable of controlling drug release in the acidic state. In a neutral environment, this capsule does not release the drug, but the membrane fusion function operates in an acidic state, and the inner and outer liposome membranes fuse, releasing the drug. It is applicable as an intelligent DDS.

### NAL Develops Equipment to Decompose Organic Waste into Inorganic Substance

94FE0400A Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 14 Feb 94 p 5

[Text] The Science and Technology Agency's National Aerospace Laboratory (NAL) trial-produced a device that quickly decomposes organic waste under a high-temperature, high-pressure environment and then converts the waste into inorganic substances. The device, which uses a titanium compound as a catalyst, breaks down rabbit manure into components that form fertilizer materials. The effort is a part of NAL's research on a "mini earth" in which human beings as well as plants and animals are completely self-sustaining in a closed environment. Because the device does not produce any noxious by-products and is compact, it is expected to be useful in realizing manned bases on the moon and Mars in the future.

The research involved the trial-production of equipment that connects a catalyst tank to a tank that creates a 300°C, 100-atmosphere environment, and then experiments to convert rabbit manure dissolved in water into materials. NAL researchers were able to confirm that 99.9% of the nitrogen components in the organic substance, and 99.7% of the carbon components, change into nitric acid, carbon dioxide, and nitrogen. The nitric acid forms a fertilizer material, and the carbon dioxide can be used in plants' photosynthesis.

The researchers also ascertained that when the catalyst is a titanium compound, it can be re-used five to twenty times. That is a big advantage in closed spaces with only limited resources. Conventional aluminum-compound catalysts can be re-used only two or three times.

A future topic is cultivating plants in liquid solutions of the decomposed components. In tests thus far, nickel dissolved from the device because of the high temperature and high pressure and mixed in with the decomposition liquid; the nickel inhibited plant growth. Now, however, NAL researchers say that they can solve that problem by coating the inside of the device so that nickel will not dissolve out of it.

In addition to rabbit manure, NAL researchers plan to test the device on crude rubber and a wide range of other waste substances.

### Tohoku University Develops Electrode Material for SOFC

94FE0400B Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 4 Feb 94 p 5

[Text] SENDAI—A research group made up of Professor Toshio Hirai and Assistant Professor Takashi Goto of Tohoku University's Metals and Materials Laboratory and Lecturer Roberto Barugas of Mexico's National Science and Technology University, in cooperation with Japan Storage Battery Co. (Shige Negishi, president),

succeeded in developing a new electrode material. Possible applications of the material include its use in oxygen-gas sensors and in solid-electrolyte fuel cells, which are being researched as third-generation fuel cells. An important feature of the new electrode material is that its maximum characteristics are brought out at a low temperature of about 300°C, which is more than half as low as that of the conductive-ceramic electrode materials used in present-day solid-electrolyte fuel cells. The researchers developed the new electrode material by using metal organic chemical vapor deposition (MOCVD) to form indium acetyl acetonate on a substrate, and then forming a film that was an aggregate of ultrafine particles 20 to 30 Angstroms in diameter, which served to enlarge the area of the electrode's surface. The new electrode material is also superior in terms of material degradation, and it is gaining attention as a result that will have applications in various next-generation materials.

Fuel cells are clean and highly effective in energy conservation. Said to be "the fourth source of electrical power," fuel cells have evolved over three generations. First-generation phosphoric-acid fuel cells, which use an aqueous solution of phosphoric acid as the electrolyte, are almost at the practical level now. In addition, research is progressing on second-generation fused-carbonate fuel cells and third-generation solid-electrolyte fuel cells.

Conductive ceramics have been used for the electrode materials of solid-electrolyte fuel cells, but the temperatures at which they exhibit good characteristics are limited to a high range, 700 to 800°C.

There has been a need for electrodes that work at low temperatures: as the temperature gets higher, the efficiency of a fuel cell's electrodes decreases, and, in the case of oxygen gas sensors, there is the problem of material degradation at higher temperatures.

The newly developed electrode material was made by using MOCVD to deposit indium acetyl acetonate on a substrate of stabilized zirconia. The researchers synthesized a smooth, homogeneous thin film of 20- to 30-Angstrom fine particles on the surface of the substrate.

The fine-particle thin film serves to increase the surface of the gas-electrolyte-electrode interface, which in turn speeds up the reaction. The new electrode material is outstanding in that its maximum characteristics (the theoretical value of the maximum electromotive force) are brought out at a low temperature of about 300°C, which is more than half as low as that of the platinum paste or sputter films used for the electrodes of conventional zirconia solid electrolytes.

The researchers also ascertained that the optimal conditions for synthesizing the thin film are for the raw materials to be at a temperature of 180°C, and for a total pressure of two to five torr within the furnace. "Being

able to make electrodes that exhibit maximum characteristics at a low temperature will enable changes in the overall design of fuel cell systems, and it will have a big impact on efficiency and costs," says Professor Hirai.

**Osaka Gas Co., Kobe Steel Develop  
Reliquefaction Technology for Gasified LNG**

94FE0400C Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 4 Feb 94 p 13

[Text] Osaka Gas Co. and Kobe Steel used coldness-storing techniques to develop technology for reliquefying boil-off gas (BOG), which is the portion of the liquefied natural gas (LNG) stored within a tank that vaporizes. Developed as a new system for exploiting the temperature of LNG, the technology can reduce the amount of electrical energy needed for reliquefaction to 40-50% of that needed with conventional BOG processing methods. Demonstration tests of the technology at an experimental facility constructed at the Senboku Plant have already concluded, and Osaka Gas and Kobe Steel will proceed with inspections geared toward the construction of an actual plant.

Now, BOG is taken out of tanks by highly pressurizing it with a compressor and then mixing it with LNG that was gasified by an LNG vaporizer. In order to increase the pressure, however, a great deal of electrical power is needed, and that has become a problem. The newly developed system stores the coldness of LNG and then uses the coldness to reliquefy the BOG at that temperature. The system is special in that it utilizes the latent heat of solidification of a hydrocarbon coldness-storing agent to keep a very low temperature (-160°C to -130°C) so that a large amount of coldness is stored per unit of coldness-storing agent.

**MHW, AIST, EA Propose Development of SOx,  
NOx Emission Control Technologies for China,  
East Asia**

94FE0400D Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 3 Feb 94 p 6

[Text] The MHW Institute of Public Health (Eiji Yokoyama, director), in cooperation with the AIST National Institute for Resources and Environment (Nagayuki Yokoyama, director) and the EA National Institute for Environmental Studies (Atsunobu Ichikawa, director), proposed SOx (sulfur oxides) and NOx (nitrogen oxides) emission control technologies for China and other developing countries in East Asia. The institutes are proposing fluidized-bed combustion and other technologies, in correspondence with the state of affairs in the areas. Now, detailed studies are being conducted for the purpose of making those technologies practical.

The institutes investigated various technologies that either have been put to practical use in the world or are being tested. From technologies 1) for removing sulfur and nitrogen from fossil fuels, 2) for suppressing NOx formation by improving combustion methods, and 3) for

flue-gas denitrification and desulfurization, the institutes selected those technologies that can be used in China. The institutes also surveyed and spoke with engineers at steelmaking plants, oil refineries, and thermal power plants in Shanghai, Beijing, and Chongqing.

The result of those efforts were proposals that the following four methods can be used in China: fluidized-bed combustion, flue-gas desulfurization using discharged aqueous ammonia, flue-gas desulfurization by means of high-pH (hydrogen ion concentration) river water, and flue-gas desulfurization by means of magnesium carbonate. That which is deemed suitable in a given area is that which is appropriate in correspondence with the local situation. For example, in Chongqing, where there are many ammonia plants, desulfurization with discharged aqueous ammonia makes ammonium sulfate. Flue-gas desulfurization by means of high-pH river water is not very efficient, but it is inexpensive in places where the soil is alkaline.

As part of the expenses for promoting global environmental research, the institutes are conducting research on technologies for controlling emissions of SOx, NOx, and other substances causing acid rain that come from East Asia and China, primarily. Along with the rapid growth of industry in this region, a tremendous increase in energy consumption is anticipated. On the other hand, introducing the kinds of flue-gas desulfurization and denitrification technology used in Japan is difficult for China because of the cost constraints and the maintenance and management technology.

In the on-site survey, the institutes' engineers found that at Chongqing thermal plants flue-gas desulfurization equipment like that in Japan, which uses a lime-gypsum method, is installed, but has hardly ever been used. The reasons why the equipment is not running are, that the maintenance is too expensive and that the gypsum by-products from the desulfurization are not needed because the area around Chongqing produces high-purity gypsum. So, the institutes proposed technologies that are not only simple, inexpensive, and convenient, but also make the most of the local characteristics. The institutes are now moving forward with research to make those technologies practical.

**Osaka Gas Co. To Construct Four Refueling  
Stations for NGVs**

94FE0400E Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 3 Feb 94 p 15

[Text] In order to accelerate the spread of natural gas vehicles (NGVs), Osaka Gas Co. will set up four new compressed natural gas (CNG) refueling stations during FY94. In addition to the 30 or so new NGVs brought in as company cars at Osaka Gas, about 50 NGVs have been acquired by the Osaka municipality for a total of about 80 vehicles.

Along with electric cars and methanol-powered cars, there are increasing opportunities for the introduction of low-pollution NGVs by the local governments of the Kinki region. MITI is also moving forward with its "Eco Station 2000 Project," in which it is setting up and maintaining fuel supply facilities. In addition to that project, Osaka Gas is now constructing CNG refueling stations in Kyoto and Mihara-machi in the southern part of Osaka Prefecture. The four refueling stations planned for 1994 are a part of that, which will add up to a total of eight CNG refueling stations in the region.

The 80 new NGVs consist of 50 passenger cars and 30 large vehicles.

#### **Chugoku Electric Power Co. Develops Generator Hydrogen Gas Purity Retainer**

94FE0400F Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 2 Feb 94 p 17

[Text] Chugoku Electric Power Co. developed the first "generator hydrogen gas purity retainer" in Japan that is made with a hydrogen-storing alloy. With the device, which increases the efficiency of electric power generation, Chugoku Electric Power Co. succeeded in maintaining a purity of 99.5% and better in the hydrogen gas it uses for generator cooling. The device will go into actual use starting in June at the Shimonoseki power plant (coal-fired) No. 1 unit (output, 175,000 kW). The cost of the development was about ¥ 70,000,000 (including demonstration test equipment). The device was judged as excellent at the Energy Conservation Promotion Convention on 1 February, and Chugoku Electric Power Co. received the Minister of Industry's award.

The device consists of two filling vessels made of hydrogen-storing alloy, one recovery vessel, a control board, and hot-water equipment. Hydrogen gas from within the generator is brought into the cylindrical purification vessel containing the alloy; only hydrogen gas is stored inside the alloy. The alloy is heated to circulate the hydrogen gas, which returns to the generator.

During the circulation, air that penetrates through the bearing sections, etc., or any other impurities are expelled so as to increase the purity of the hydrogen gas. The job of increasing the purity is automatic, obviating the need to replace the high-purity gas that has gone around one time, as done in the past.

Maintaining the hydrogen gas purity at 99.5% or higher decreased the gas resistance loss during rotation of the generator's rotor (the windage loss) by 30% and increased the generating efficiency by 0.08%. For the Shimonoseki No. 1 unit, use of the device will lead to an increase of 840,000 kW per year in the amount of electrical power, which would save the equivalent of 300 tons of coal per year. The shell-and-tube alloy vessel is made of a misch metal-nickel hydrogen-storing alloy.

Chugoku Electric Power Co. started the development of the device in 1987, and has conducted demonstration

tests from April 1989 to September 1993. Mitsubishi Heavy Industries was commissioned with the production of the hard parts of both the demonstration device and the actual device. The cost of producing the actual device was about ¥ 30,000,000.

#### **Yokohama National University Confirms PCB Detoxification Technology Using Explosive Reaction**

94FE0400G Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 1 Feb 94 p 6

[Text] Yokohama National University Professor Terutoshi Ogawa and his assistant, Junji Miyake, confirmed that detoxification technology using an explosive reaction can be applied to toxic liquid wastes in the same way as with gases. When the researchers put freon-113, which is used for washing electronic parts, into a sealed vessel and detonated it with explosives, more than 99% of the freon-113 decomposed. Although a rigorous analysis of the decomposition products remains an issue, the researchers found that it may be possible to use simple, inexpensive equipment to process liquid wastes that are difficult to break down. In particular, the technology is expected to tie in with the decomposition and detoxification of polychlorinated biphenyl (PCB), a toxic substance that can only be stored as is because there is no effective technology for processing it.

This technology uses the explosion's high-temperature, high-pressure detonation wave (an explosion in which the surface of the combustion wave moves at a speed of several tens of meters per second) to instantaneously add heat and pressure to toxic substances and thereby break them down. In May 1993 Ogawa collaborated with the Kanagawa Prefecture Industrial Test Station and developed technology for breaking down freon-12 by exploding it. There are good prospects for making the technology practical.

Ogawa and Miyake applied the technology to the decomposition of liquids. The technology is targeted at the many ozone-destroying freons and alternative freons that are in liquid form. Another target is the processing of PCB, storage of which is mandatory because there is no other processing technology that is acceptable to the public. The researchers' experiments were done with non-toxic freon.

Ogawa and Miyake filled a sealed container with freon-113 and an explosive, then applied energy from the outside to detonate the explosive. They confirmed that, with a 3,000°C, 300-atmosphere detonation wave, 99% of the freon-113 decomposed into hydrogen fluoride, hydrogen chloride, carbon dioxide, water, etc. In the case where a liquid with an explosive is analyzed, however, a rigorous analysis is difficult, so the researchers' next issue is the detailed analysis of whether or not toxic products are left over.

In addition, because hydrogen fluoride and hydrogen chloride corrode metal, the life of the sealed container

becomes a problem. For that reason Ogawa and Miyake will conduct further research on the kinds of explosive reactions that do not produce those gases. Their ultimate goal is to develop practical technology using simple equipment for low-cost processing of both liquid and gaseous wastes that are difficult to break down.

**Tokyo Electric Power Co. To Test Heat Pump that Uses Freon Substitute**

94FE0400H Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 1 Feb 94 p 15

[Text] On 1 February Tokyo Electric Power Co. announced that it had begun demonstration-test operation of a large-scale heat pump for a local heat supply that uses HFC134a—a freon that does not contain any chlorine, which is the chemical that damages the ozone layer.

The heat pump has the cooling power of about 1,000 typical household air-conditioners (750 tons of refrigeration). Tokyo Electric Power Co. set up the heat pump at the "Kyobashi 2-chome" (in Tokyo's Chuo District) local heat supply, where a related company, Tokyo Electric Power Real Estate Management, will start business operations on 1 March. After business operations start, the area will be supplied with hot water and cold water produced by the pump. Other examples of heat pumps that use non-ozone-depleting freon are mid-scale and smaller heat pumps for the air-conditioning systems of individual buildings. This is the first large-scale heat pump for a local heat supply system. Kyobashi 2-chome is a local heat supply system based on a stored-heat type of heat pump; it will use night-time electrical power to produce hot and cold water, store it in heat-storage tanks and then supply it to customers. There is also another heat pump facility (750 tons of refrigeration) that uses a specific freon, HFCF-22. The peak-shift effect of the two facilities together will be about 700 kW, and the energy-conserving effect will be equivalent to 3,065 drums of A fuel oil.

**Wako Sangyo, MCC Develop Equipment to Convert Plastic Waste into Oil**

94FE0400I Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 4 Feb 94 p 13

[Text] NAGANO—Wako Sangyo (Nagano City), a maker of industrial waste processing plants, announced that it formed a technical tie-up with MCC (Nagano City) and developed five types of reduction equipment that converts plastic wastes into oil.

In general, the equipment converts the plastic wastes from chemical plants or industrial waste processing plants into oil and then turns the oil into fuels such as

petroleum and kerosene. Given the difficulty in securing disposal sites for industrial waste, Wako Sangyo developed the equipment to reduce the work involved in collecting industrial waste and transporting it to disposal sites, and to enable the company itself to re-use plastic waste as fuel. The equipment's processing capacity is 300 kg to 3 tons (in eight hours); the cost ranges from ¥25,000,000 to ¥170,000,000. The company plans to sell 30 units during the first year to factories, industrial waste dealers, and local governments.

The equipment consists of a melting furnace, a heat exchanger, and a de-oiler. Plastic and styrene foam are brought into the melting furnace, melted with a heat of 1,200°C, and then collected in a container.

The plastic waste is reheated to 1,500°C as it passes through screw-shaped diagonal pipes, then the oil is gasified. The gasified oil is cooled by the heat exchanger, passes through a filter, and is then refined into fuels such as light oil, A fuel oil, and kerosene. Any metals present at that time are eliminated from the diagonal pipes by the gasification process.

**Dowa Mining Co. Develops Process to Treat Melted Heavy Metal Waste**

94FE0400J Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 1 Feb 94 p 15

[Text] Dowa Mining Co. developed a process to treat the airborne ash (melted airborne ash) generated when waste incineration ash and sewage treatment sludge undergo melting and solidification. The melting method for treating the ash to reduce its volume is considered a good prospect, but there is a problem in that heavy metals revolatilize at high temperatures and become concentrated in the airborne ash. With its own original process (patent pending) Dowa Mining Co. succeeded in separating heavy metals from the ash to render it harmless. The company has begun testing the process with a demonstration plant; the next goal is to make the process practical.

When urban waste is incinerated, about 10% of it becomes cinder and 5% airborne ash. Because the ash contains heavy metals and other such toxic substances, it is regulated by law so that it is treated as a specifically controlled waste.

Methods of treating heavy metal waste include concrete solidification, melting, chemical treatment, and solvent extraction.

Gaining attention among those is the melting method, in which very high temperatures are used to detoxify and reduce the volume of the heavy metals contained in the

ash. There was a problem, however, in that heavy metals volatilize at temperatures above 1,200°C and become concentrated in the airborne ash.

To deal with that Dowa Mining Co. researched methods of separating heavy metals at the Environmental Technology Research Institute (Kosaka-machi, Akita Prefecture). Then the company developed an original process that recovers more than 99% of heavy metals such as lead, zinc, and cadmium.

There is also the possibility that those metals that are separated and recovered can be recycled into refined raw materials.

Dowa Mining Co. set up a demonstration plant and began continuous tests of the process for the purpose of making it practical. In the future the company will work to get local governments that plan to use the melting method to adopt its process, and will investigate systems for recycling the recovered metals.

**Plastic Waste Management Institute Recovers Energy at Rate of 87 Percent From Plastic Waste**

43070105A Tokyo JAPAN CHEMICAL WEEK  
in English 5 May 94 p 8

[Text] Plastic Waste Management Institute, together with Ebara Corp., has succeeded in recovering energy at the rate of 87 percent (boiler efficiency) from plastic waste separated from garbage: they burnt the waste with a circular flow-type fluidized-bed incinerator and thereby generated electric power without discharging harmful substances beyond tolerable levels.

Most plastic waste has hitherto been buried in Japan since it is mistakenly thought—to some extent—that, when incinerated, the waste damages the equipment employed and results in the production of harmful gas, soot, clinker and even dioxin.

Their successful results are expected to help local governments rectify their policies for waste disposal.

Ebara has installed in Japan 10 units of the said equipment and is building or test-running it in four locations in the European Union. In the incinerator's fluidized bed, silica sand is circulated vertically by an air flow, thus providing optimum burning conditions.

**Metal Mining Agency of Japan to Establish Research Center for Mine Pollution Prevention**

94FE0606D Tokyo NIHON KOGYO SHIMBUN  
in Japanese 24 Feb 94 p 1

[Text] The Metal Mining Agency of Japan (MMAJ; Director: Mr. Takashi Ishikawa) hopes to establish, before the end of 1994, a research institution with the provisional name of "Resources Technology Research Center" (RTRC), for such purposes as strengthening measures to prevent mining pollution and promoting research on exploration technology in the metals area. This is the first time that the MMAJ will possess its own research institution; the MMAJ aims to use the RTRC to build an effective and centralized research system. The forecast is for the RTRC is to begin full-fledged research activities in Fiscal Year 1995. A total of 450 million yen will be invested in the RTRC, and the nation will provide the entire sum of money as new investment.

The objectives of the RTRC include: strengthening measures to prevent mining pollution, improving prospecting development technology, and promoting the recycling of mine resources. Over the next month or two a working group set up in the MMAJ will tackle "concept design" concerning such matters as determining how to proceed with the work, where the RTRC should be located, and outlining the facilities that the RTRC possess.

Up to now the MMAJ has relied upon outside help for research and development, but possessing its own research facilities will expedite the development of technology for pit waste-water disposal in metal mines,

promote the effective utilization of resources, and strengthen measures to prevent mining pollution. The aim is to revitalize Japan's mining areas.

The strength of metal manufacturing firms have declined due to causes such as depressed conditions in the market for metals, thereby increasing the proportion of private-sector firm's budgets that is spent to combat mining pollution. The RTRC will be the first government institution to conduct research on mining-pollution prevention technology, and the plan is to begin work on the Center as soon as a blueprint for facilities can be drafted and other such matters addressed.

According to a report recently compiled by the Mines Subcommittee of the Mining Industry Council (an advisory body to the Minister of International Trade and Industry), pointed out that in the future smelting in Japan could be improved by (1) forming a recycling system that would function even when prices are depressed, and strengthening the development of recycling technology, and (2) mounting a long-term effort to develop environmentally friendly smelting technology. The RTRC would be established in a manner corresponding to this sort of mid- and long-term vision for the non-ferrous metals smelting industry. The MMAJ is a special corporation entirely funded by the government and established in 1963 for the purpose of providing for an inexpensive and stable supply of metal mining products, and developing Japan's metal mining industry. It will tackle tasks such as the prevention of mining pollution in addition to promoting prospecting for and developing metal mining resources with Japan and abroad, and stockpiling metals.

**AIST Develops Film Photocatalyst for Wastewater Treatment**

94FE0606A Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 25 Mar 94 p 5

[Text] The Nagoya Government Industrial Research Institute (Director Yasuhiko Kondo) of the Ministry of International Trade and Industry's Agency for Industrial Science and Technology (AIST), acting in cooperation with a member firm of Kyodo Kumiai Photoknack, has developed a maintenance-free film photocatalyst that can continuously dispose of sewerage and industrial waste water, including that containing organic chemicals that are difficult to treat biologically with microorganisms. The Institute maintains that organic matter contained in waste water can be effectively broken up through oxidation merely by exposure to the sun's rays when materials such as glass are covered with titanium dioxide by using a sol-gel method, and that this process can be used safely, inexpensively, and semi-permanently. Good results have been obtained in experiments using aqueous solutions of tetrachloroethane, a substance that is widely employed in high-tech industries and in the cleaning business, et al., in products such as cleaning fluids. The new process will likely be commercialized.

Pollution caused by various chemical substances, such as organic chloride solvents and agricultural chemicals on golf courses, is on the increase world-wide, but such pollutants are difficult to eliminate with water treatment methods currently in wide use like the activated sludge method. By contrast, decomposition utilizing electrons generated by the action of solar radiation on semiconductors and the oxidation and reduction potential of holes has many benefits and is viewed as promising, but all of the processes that have been developed up to now have involved powdered forms. For that reason separation with processing liquids has been difficult, and continuous operation was not possible because of problems such as clogged filters.

To overcome such problems, the Nagoya Industrial Research Institute mounted a joint effort with Photoknack member firms, such as Aiwa (located at Iwakura City in Aichi Prefecture), Kato Kikai Seisakusho (Komaki City in Aichi Prefecture), and Ozawa Kagaku (Nagoya). Together, the Institute and the firms successfully developed a maintenance-free thin film photocatalyst that makes possible continuous operation with superior durability.

Trial manufacture and experiments with the new process revealed that pollutants in waste water can easily be decomposed by creating a thin film (10 layers of coatings, film thickness of 0.7 millimeters, film length of eight centimeters) of titanium dioxide on the surface of a glass tube eight millimeters in external diameter through a sol-gel method made from titanium alkoxide, immersing it into a 100 parts-per-million aqueous solution of tetrachloroethylene, and shining a light (a 300-watt xenon lamp) on it.

Furthermore, when researchers added minute quantities of iron salts present in ordinary waste water, decomposition was as much as three times quicker, thus establishing the new process' great practicality for use as a photocatalyst to treat waste water.

Finally, the thin film of photocatalyst material is sintered, so it is durable, transparent, and its surface takes on a porous configuration. Surfaces of ceramics, such as glass, and metals, such as aluminum, can be coated as various shapes, such as rods, tubes, plates, and spheres, can easily be accommodated. Titanium dioxide is used in dentifrices like toothpaste as well as in cosmetics and as a raw material for painting automobiles white; it is non-poisonous and inexpensive. It not only absorbs ultraviolet rays, but also light that has a wavelength in the vicinity of 500 nanometers longer.

#### **150 Japanese Manufacturers To Establish Research Institute to Develop Substitute Cleaning Agent**

*94FE0606B Tokyo NIKKAN KOGYO SHIMBUN in Japanese 24 Mar 94 p 1*

[Text] On 13 April, 150 companies, such as Toshiba Corp. and Shimada Kakogyo, which are equipment

manufacturers and firms that produce substitute cleaning agents which do not pollute the ozone layer, will establish a consultative group for classifying systems of substitute cleaning-agent technology and providing for the establishment of better cleaning technology. The deadline at the end of 1995 for eliminating the use of chlorofluorohydrocarbons and trichloroethane is fast approaching, and a variety of substitute cleaning agents have come on the market to do so. Nevertheless, no headway was being made in the ethane area in particular; small- and mid-sized firms overwhelmingly occupy the majority of ethane users. For that reason, concerned firms have joined forces for a common cause, and will make a smooth transition to substitute cleaning agents and will develop superior cleaning agents.

Ethane substitutes are about to replace the use of ethane in the 200,000-ton ethane market, and firms which have embarked on the use of ethane substitutes up to now include 180 solvent manufacturers, 150 machinery manufacturers, and 300 manufacturers of peripheral equipment. Currently, small- and mid-sized firms make up 70 percent of all firms using ethane. Those firms have fallen behind to a great extent in switching to ethane substitutes. That is because in addition to suffering from the recession, ethane users have been uncertain as to which of the various substitute cleaning agents and equipment that have appeared on the market would be good to employ in their businesses. Given this situation it has been decided that firms involved with substitute cleaning agents will band together, establish the Japan Industry Cleaning Association, and actively back up efforts to achieve a smooth transition on the part of ethane users to substitute cleaning agents.

#### **Japan To Conduct Research on Acid Rain with China**

*94FE0606C Tokyo NIHON KEIZAI SHIMBUN in Japanese 4 Apr 94 p 15*

[Text] Researchers employed at Japan's and China's research institutions and universities will embark upon a joint research effort in an attempt to elucidate the relationship between acid rain and loess ((rich yellowish soil)). Together they will explore the workings of loess, which can be described as both transporting and neutralizing sulfuric oxides (SOx) and nitrous oxides (NOx), substances that cause air pollution. There is a possibility that air pollutants are blowing over to Japan from China, a country where environmental damage is feared from a one-sided emphasis upon economic development, but this concern has not been adequately researched. It seems that international momentum is building to research ways to prevent acid rain and air pollution.

The institutions to undertake joint research include: the National Public Health Academy, the National Environmental Institute, Saitama University, and Fukuoka Prefecture's Health Environment Institute on the Japanese side, and the China-Japan Friendship Environment Protection Center on the Chinese side. The research will

consist of gathering samples of loess from the areas in China where it is generated, such as Lanzhou, Sian, and Yinchuan, as well as locations in China where loess falls, such as Beijing, then comparing its composition with that of loess in Japan that has fallen in areas such as Fukuoka Prefecture, and analyzing the proportion of sulfuric oxides that cause air pollution contained in the loess samples of both countries. The research will also scientifically explain the relationship between loess and substances that cause acid rain, by spraying sulfuric acid on to loess collected in China and investigating the action of the loess in counteracting the pollutant.

Loess is picked up by the wind in China's loess plateaus, as well as in areas such as the Takhlamakan and Gobi

deserts, and blown over with the prevailing westerlies; it is often observed in Japan during the spring. It is said that the beginning of spring is a time when there is a great increase in the arrival in Japan of substances causing acid rain blown over from the Chinese mainland. Moreover, there is a belief that loess itself neutralizes substances causing acid rain because it has considerable alkalic content.

Tsugio Mizoguchi, Dean of the National Academy of Public Health's Faculty of Regional Environmental Health says that "We will ascertain through a joint Chinese and Japanese research effort whether loess contributes to softening the effect of acid rain on our two countries."

### **Overall Yield Rapidly Climbs to About 70% at NEC New Liquid Crystal Plant**

94FE0656A Tokyo NIKKEI MICRODEVICES  
in Japanese May 94 pp 88-89

[Article by Hiroichi Funaki]

[Text]

#### **NEC's Kagoshima TFT Plant Thoroughly Automates its Conveyance System**

In April 1994 NEC's Kagoshima TFT color liquid crystal second-term line recorded an overall yield of about 70%—a 90% yield in the TFT array processes, 85% in the liquid-crystal cell processes, and 90% in the packaging processes. Since the input of glass substrates in December 1993, the overall yield climbed rapidly in only four months. By May, the plant will have the capacity to attain an overall yield of 80%. The sudden rise in yield is said to result from the thorough automation of the glass substrate conveyance. Except for inspections, most of the processes are being automated. The line's production capacity, based in terms of glass substrates, started from 10,000 per month and by October should rise to 15,000 per month.

"We will aim for first place in the liquid-crystal market," declared Tadamitsu Sekimoto, president of NEC, at a press conference at the celebration of completion of the NEC Kagoshima second-term line on 13 April. Because of that, NEC "will achieve a 30% share and sales of ¥200 billion in FY96."

Even though NEC does not know where the current market leader, Sharp, will be in FY96, "the first step toward being at the top in the liquid-crystal market is the completion of the second-term line," says Mr. Sekimoto. NEC plans to boost its sales, which were ¥42.0 billion in FY93, to ¥100.0 billion in FY94, ¥150.0 billion in FY95, and ¥200.0 billion in FY96.

#### **A Vertical Climb to an Overall Yield of 80% in May**

The NEC Kagoshima second-term line first input 360 x 465 mm<sup>2</sup> glass substrates in December 1993. By April 1994, a mere four months later, the line's overall yield rose suddenly to about 70%. That is vastly different from the first-term line, which took three and a half months until it could get a good product. The second-term line is capable of attaining an overall yield of 80% by this May.

What made this vertical rise possible were the effects of "eliminating people, and implementing strict maintenance control," says T. Iwakawa, president of NEC Kagoshima. "As a result of thoroughly automating the glass substrate conveyance, we reduced the number of people working in the clean room by about half." In comparison with the 400 workers on the first-term line, the second-term line gets by with 200 workers. The subject for workers whose main jobs were conveyance of

glass substrates changed to the subject of maintenance. It is along the lines of the original idea to have people working only in maintenance.

The 200 workers on the second-term line work in four shifts, and all of the processes are covered by 50 workers. A general breakdown is 15 people working on the TFT array process, 15 people on the liquid-crystal cell processes, and 20 people on the packaging processes. For example, on the TFT array process, four or five workers move around in the clean room for the purposes of monitoring and cleaning. The other workers are in charge of inspections, which cannot be automated yet.

#### **Backlight Mounting Completely Automated**

The automatic conveyance consists of automatic ground vehicles (AGVs) and stockers. The system transfers one-lot, 20-substrate carriers from device to device. The TFT array processes and liquid-crystal cell processes are completely automated. As for the packaging processes, some of the conveyance still requires human hands, but the TCP crimping and soldering device and the backlight mounting device are automated. In the future course of adding more devices, NEC is also heading toward 100% automation of the conveyance, too.

People are still in charge of the final lighting inspection. Automated image-quality inspection devices are sold by a number of companies, but the throughputs are still low, and the prices are too high. This time NEC says that it has shelved the idea of using such devices.

The productivity of the second-term line is three times that of the first-term line. The larger, 4-bevelled glass substrates double the productivity, and the increase in throughput, including operation rate, raises the productivity by 1.5 times for a total three-fold improvement in productivity over that of the first-term line. Whereas the throughput of the first-term line is 60 seconds tact, that of the second-term line is 45 seconds tact. However, the tact time is in a state where fast and slow [processes] are mixed together.

The operation rate remains at 60%, even for the second-term line in which only the CVD operation rate is low. For that reason the situation is one of waiting for the realization of self-cleaning technology. On the other hand, because the other devices have more than enough capacity for 10,000 substrates per month, it still does not show in the operation rate. For example, one device that makes the washing to rubbing processes in the liquid-crystal cell processes inline has the capacity for 30,000 substrates per month.

Thus, because of the many devices that are not yet operating at their full capacity, the second-term line is expected to ultimately handle 30,000 substrates per month. But, by pursuing balance in the line, the possibility of achieving 40,000 per month also remains.

**Sharp Produces Reflective-Type Color Liquid Crystal Panel Reduces Power Consumption to 1/30 of Past Types**

94FE0661A Tokyo NIKKEI ELECTRONICS  
in Japanese 25 Apr 94 pp 18-19

Sharp has produced a reflective-type color liquid crystal panel which doesn't use backlighting. The screens measures 5 inches. The screen's resolution is 640 x 240. The screen can show cyan and red in addition to white and black. The screen's electrical consumption is 50mW since it doesn't use a light source. That is as little as 1/30 of existing size 5 color liquid crystal panels. It is likely to be used in portable information apparatus to make the most of its light weight and low energy consumption.

The distinctive characteristic of the recently developed reflective-type color liquid crystal panel is that it produces bright images without using the polarizing plate that was essential until now.

When a polarizing plate is used, the strength of light beams incident on the liquid crystal panel was reduced to less than half by passing through the polarizing plate. Accordingly, the screens of reflective-type liquid crystal panels which do not use backlighting will darken. This is a weak point of these screens.

Energy consumption rises greatly when backlighting is used to adjust for darkness. Also, the thickness and weight of liquid crystal panels increases.

**Use of Guest-Host Liquid Crystal**

Sharp has made a polarizing plate unnecessary by using guest-host liquid crystal with TFT (thin film transistors) panels in place of the TN (twisted nematic) panels used until now (see Figure 1).

A guest-host liquid crystal is a mix of crystal (host) with coloring guest). When voltage is not applied, the coloring molecules group themselves along the bare wires, in line with the liquid crystal molecules. In this state, when light beams are incident on the liquid crystal panel, the coloring will be absorbed by the light and the screen will be black. When voltage is applied, the line-up along the bare wires will end and the liquid crystal molecules and the coloring molecules will line up lengthwise. Incident light beams will pass through as is and white will appear on the screen.

Liquid crystal panels using guest-host liquid crystal have been available, but until now they could only be used for simple images such as on watches. This is because there were large electrical leaks from liquid crystal with coloring mixed in, so it wasn't possible to operate using TFT panels.

Now Sharp has developed new coloring and liquid crystal materials which reduce electricity leaks to the level of existing TN panels. They've combined these

materials into TFT panels. However, the current prototype color liquid crystal panel can only display cyan and red in addition to white and black (Figure 2).

Usually color liquid crystal panels display multiple colors using red, green, and blue color filters. The screen is darkened since the color filters cut the strength of incident light to less than one-third its original strength. The current prototype uses cyan and red color filters. This decreases the number of colors displayed, but only about half of the light is lost, making the display much brighter.

**Two-Layer Construction of Pixel Electrodes and TFT**

The maximum outside reflectiveness rate of the color liquid crystal panel is 30% (the reflectiveness rate when light is shined on white paper is 100%). This almost rivals the rate of newspapers.

Measures were also taken with the TFT panel to preserve brightness. The usual TFT panel has its pixel electrodes on the same surface as the TFT and wiring. This decreases the area of the TFT/wiring and of the image elements. Generally, the area of the image elements is reduced to half of the image surface. The light which passes through the panel is also halved.

The recently developed color liquid crystal panel enlarges the area of the image elements with a two-layered structure of image electrodes and TFT. The image electrodes also serve as a light-reflective board. The light incident on the liquid crystal panel passes through the liquid crystal layer and is reflected by the image element electrode surface and is radiated to the outside of the liquid crystal panel.

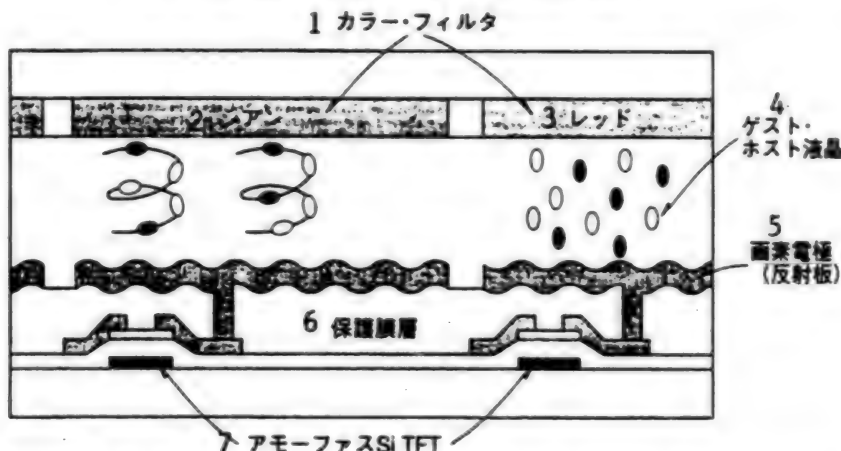
If the surface of the pixels which acts as the reflective board is flat, then the reflected light will all be reflected to the surface of the liquid crystal panel. Then the degree of brightness could vary greatly according to the angle. To prevent this problem, minute bumps are put in the image element electrodes, so light will be dispersed by the reflective board surface.

Energy consumption of this color liquid crystal panel is only 50 mW, or about 1/30 that of previous boards, since backlighting is not used. This color liquid crystal panel was created for use in equipment, such as portable information apparatus, in which energy conservation is essential.

**Entry in MIM Liquid Crystal Panels**

Sharp has also developed a MIM (metal insulator metal) liquid crystal panel for use as a black and white liquid crystal panel to be viewed straight-on (see Figure 3). Two types of panels were produced. First, a 4.7 inch liquid crystal panel (320 x 240 image elements) for use in portable information apparatus. Second, a 10.7 inch liquid crystal panel (640 x 400 image elements) for use in

**Fig 1. Structure of Reflective-Type Color Liquid Crystal Panel Uses guest-host liquid crystals. Image element electrodes made up of Al. Enlarges image electrode surface by using two-layered construction of image electrodes and TFT. Organic material used for protective film.**



Key: 1. Color filters; 2. Cyan; 3. Red; 4. Guest-host liquid crystals; 5. Image element electrodes (reflective boards); 6. Layer of protective film; 7. Amorphous Si TFT

word processors. Electrical consumption has been held down to 10 mW for the 4.7 liquid crystal panel which is a reflective-type panel.

While a TFT liquid crystal panel uses three-terminal transistors for every image element, a MIM liquid crystal panel uses 2-terminal diodes for every image element. Currently Seiko Epson and others mass-produce these for use in liquid crystal television and video game machines. Their picture quality falls in between STN (super nematic twisted) liquid crystal panels and TFT liquid crystal panels.

Sharp is a top provider of STN liquid crystal panels for personal computers and plans to begin producing MIM-type liquid crystal panels. Sharp says that production costs can be made "close to those for STN liquid crystal panels." Tough rivals in STN liquid crystal panels will appear.

#### **Fujitsu Develops SPARC Chip with Built-in Vector Registers for Use in Floating-Point Arithmetic**

94FE0662A NIKKEI ELECTRONICS in Japanese  
25 Apr 94 pp 22-23

[Text] Fujitsu has developed the MB86934, a SPARC chip including vector registers in a floating point arithmetic unit. FIFO (first in first out) memory is used by the vector registers. The chip is oriented toward matrix algebra such as coordinate transformation. The chip is aimed at use by photocopiers, high performance laser printers, image processing boards etc. It contains an interface that connects directly with a 60MHz synchronous DRAM.

There is demand for incorporatable 32-bit microprocessors with the high-speed image processing capability of workstations. This is spurred by the spread of products such as laser printers with resident outline fonts, digital photocopiers that can process the images they read, and game machines using computer graphics technology. There are many applications that require a high level of arithmetic capability for coordinate transformation using matrices.

Fujitsu is responding to user needs with the MB86934 (see Figure 1), the most advanced chip in the SPARClike series of RISC microprocessors for incorporation into products. The floating point arithmetic unit's registers can be used as vector registers. They use FIFO (first in first out) memory. A circuit for interface with a synchronous DRAM is incorporated to raise the speed of data transfer between FIFO memory and main memory. A 60 MHz synchronous DRAM is used.

One chip integrates 2 kilobyte data cache, 8 kilobyte instruction cache, and DMA controller. It contains a PLL circuit for running an internal clock at twice the frequency of an external clock. It contains no memory management unit. "There are almost no applications that require such a memory processing unit," says the number one design division of Fujitsu's microsystems development division.

Integer arithmetic capability at a speed of 60 MHz is 55.5 MIPS with a VAX-11/780 change. Floating point arithmetic capability is 60 MFLOPS. The chip's dimensions are 11.9 x 11.03 mm<sup>2</sup>. An area of approximately 6 mm<sup>2</sup> is taken up by FIFO memory. 0.5 micrometer CMOS technology is used. 1.15 million transistors are integrated on one chip. Sample price is ¥ 20,000. Production will begin in November 1994.

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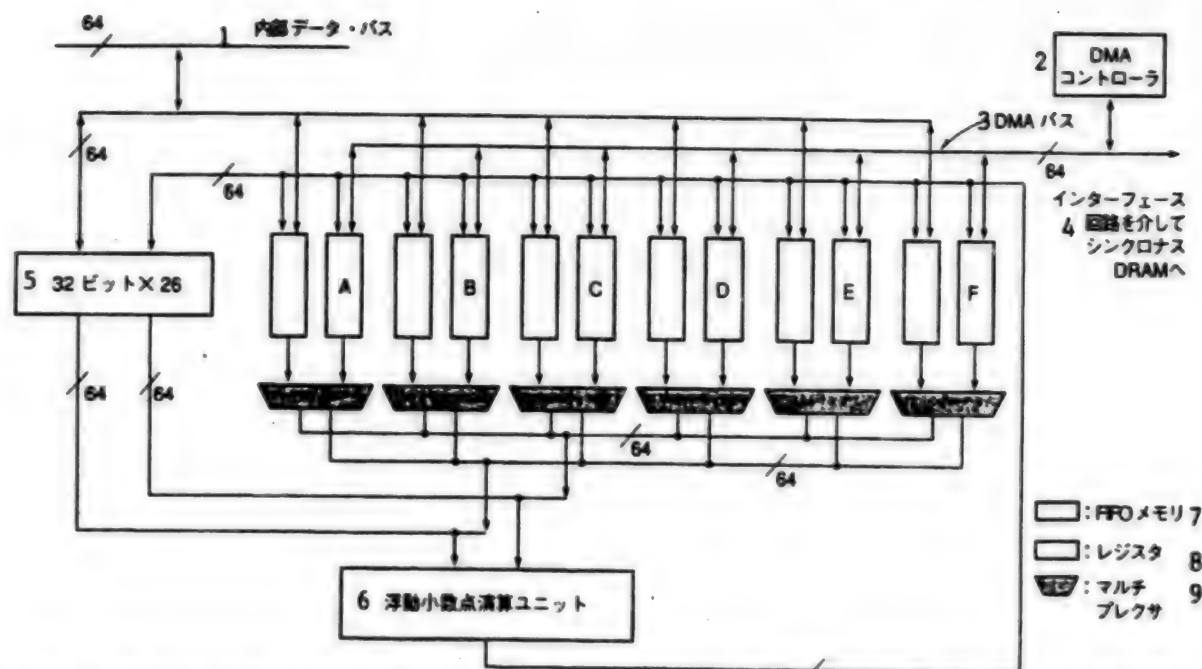


Fig. 1. Structure of six units of FIFO memory using vector registers. FIFO memory has 64 words x 32 bits. Data from main memory is sent directly to FIFO memory by the DMA controller. The data bus' width is 64 bits. Regular resistors are used for scalar arithmetic. FIFO memory and resistors are switched by multiplexers.

Key: 1. Internal data bus; 2. DMA controller; 3. DMA bus; 4. To DRAM via interface circuit; 5. 32 bits x 26; 6. Floating point arithmetic unit; 7. FIFO memory; 8. Resistors; 9. Multiplexers

### Contains Six Units of FIFO Memory.

The MB86934 contains six units of FIFO memory of 64 words x 32 bits (Figure 1). FIFO memory can be used for storing of both data used in arithmetic and arithmetic results. Usually three units of FIFO memory are used as a set. Two of the three units are used to carry out floating point arithmetic using data stored in FIFO. Arithmetic results are written to the remaining unit of FIFO memory. The depth of FIFO memory can be set. At single precision (32-bit) a configuration of a maximum of 64 rows is possible.

### Synchronous DRAM is Essential

A circuit within the chip for interface with synchronous DRAM is essential for continuous reading of data in FIFO memory.

It's necessary to conduct the following kind of processing for overhead due to data transmission during vector arithmetic. While one set of FIFO memory is used for floating point arithmetic, data transmission between another set of FIFO memory and main memory is carried out.(Figure 2).

For example, two cycles are needed for one case of integral sum floating point arithmetic which is often used in image processing. During this period, if three words (96 bits) of

data are sent between FIFO and main memory, the overhead that goes with data transmission will not appear.

Three words can be transmitted in approximately 1.9 cycles when synchronous DRAM is used. At the high-speed page mode of regular DRAM, the transmission of three words takes 12 cycles (60 MHz clock speed), so floating point arithmetic must be halted until data storage is completed

Table 1. Specifications of MB86934

Clock speed	60Mhz
Integer arithmetic capability	55.5 VAX MIPS
Power source voltage	+3.3V plus or minus 5%
Energy consumption	Maximum of 2.5W
Internal memory	Six units of 62 words x 32 bits of FIFO memory (for use in floating point arithmetic unit), 8 kilobytes instruction cache, 2 kilobytes data cache
Number of transistors	1.15 million
Production technology	0.5 millimicron CMOS, Al 3 layer wiring
Chip dimensions	11.9 x 11.03 mm
Package	256 bin ceramic QFP
Sample price	¥ 20,000

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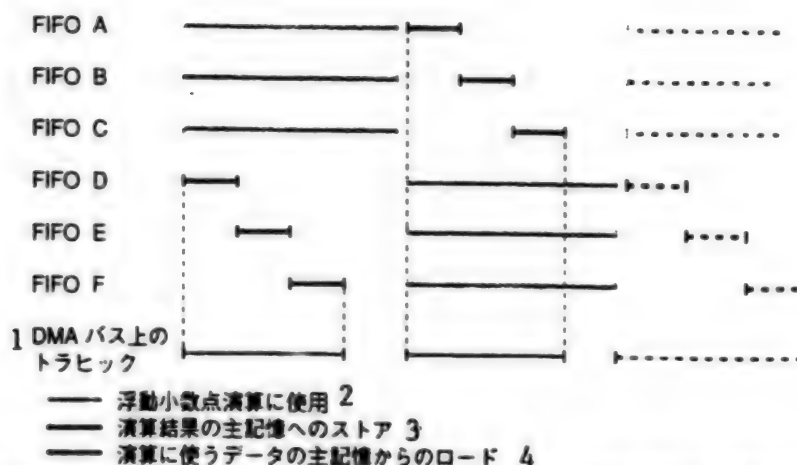


Fig. 2. Improving usage efficiency of bus used in two-set FIFO memory exchange. Three units of FIFO memory are used as one set (Two units for storage during arithmetic and one unit for storing arithmetic results). While one set of FIFO memory uses the bus connected to the floating point arithmetic unit for floating point arithmetic calculations, another set controls data storage and loading through the DMA bus. This improves the usage efficiency of the DMA bus and floating point arithmetic unit.

Key: 1. Traffic on DMA bus; 2. Usage for floating point arithmetic; 3. Storage of arithmetic results in main memory; 4. Loading from main memory of data used in arithmetic

#### Fabricating Four 26cm-Diagonal Panels per Substrate Becomes Important

94FE0560A NIKKEI MICRODEVICES in Japanese  
Apr 94 pp 83-84

[Text] The size of the "mother glass" which is used in TFT liquid crystal panels will change for the second phase of production, which is scheduled to go into operation before the end of 1994. This means that the new larger size, which is intended to set the standard, will become mixed with the 360 x 465mm<sup>2</sup> size which is already in production. To meet the increasing demand from personal computer manufacturers for the 26cm diagonal size (10.4 type) in notebook type computers, panel manufacturing companies hope to produce four of the 26cm diagonal panels per substrate. The development strategy for CVD equipment is also likely to change accordingly.

The size of the mother glass used in second phase production lines will be larger in an effort to set the standard. The new size will become intermixed with the 360 x 465mm<sup>2</sup> size panels which are already being produced.

During the planning stage for second phase production, the panel manufacturing companies tried to focus on a 360 x 465mm<sup>2</sup> mother glass for use in TFT panels. In fact, Sharp's new production line in Tenri (NF3) and NEC's second phase production line in Kagoshima have already begun production for this size. However, other latecomers which are building second phase production lines, such as Hitachi, Ltd., will produce glass panels which are 10mm larger in size.

#### Pressure for 26cm Size Also in Notebook Style Computers

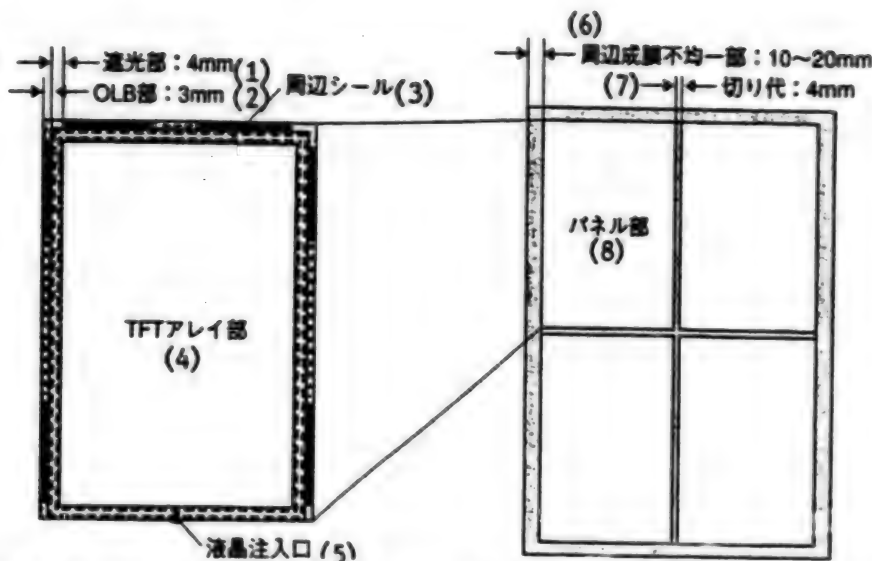
There are complex circumstances which have led to this change. As a result, the PC manufacturing companies, which are the largest customers of TFT LCD panels, joined together and began requesting 26cm panels for notebook type computers. (Refer to Nikkei Microdevices, February 1994, page 72; and March 1994, page 72.)

The first company to begin serious production of notebook computers which use the 26cm panels was IBM Corp. The first model of this type was the PS55 note N27sx (color), which came out in October, 1991. At that time, the 26cm panel was used because it was the only size in existence. However, this model had a large impact on the marketplace. Although other PC manufacturers were at first willing to follow suit with a 24cm diagonal size (9.4 type) in second phase production lines, they acknowledged that it would be better if the display area was larger even in the notebook-type computer: (according to Compag, Japan). They even began to claim that adoption of the 26cm size would be essential to compete against IBM.

#### Flexibility Could Also Be the Solution

Unfortunately, it is not easy to produce four 26cm panels from a 360 x 465mm<sup>2</sup> glass substrate. (See Figure 1 and Table 1.) However, if productivity in second phase production lines is not 300% that of first-phase production lines, and four panels cannot be produced from one substrate, there will be no profit.

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**Figure 1. Panel Periphery and Arrangement of Four Panels on Mother Glass.** This illustration shows the periphery of a current 25cm panel, and the dimensions required for four panels per substrate. At the outer edges of each panel there needs to be a section for shielding light which comes from the TFT array, and a terminal section for outer lead bonding. There is also a cutting margin required between the panels. In this area, there is a shunt wire which prevents electrostatic breakdown in the array area.

Key: 1. Light shielding area: 4mm; 2. OLD section: 3mm; 3. Periphery seal; 4. TFT array area; 5. Liquid crystal injection entry; 6. Non-uniform film growth area: 10-20mm; 7. Cutting margin: 4mm; 8. Panel area

There are two ways to achieve four 26cm panels per substrate: (1) to slightly enlarge the size of the mother glass, and (2) to slightly reduce the panels size without changing the glass size.

Hitachi and NEC have already adopted the first method. Hitachi began to use larger glass size during 1993. Although the initial plan was to achieve four 26cm panels from a 370 x 470mm<sup>2</sup> substrate, a larger glass size of 380 x 480mm<sup>2</sup> was used beginning in 1994. NEC is already using a 360 x 465mm<sup>2</sup> size in its second-phase production line in Kagoshima, but it plans to adopt the 370 x 470mm<sup>2</sup> size in its Akita plant which is scheduled to go into operation at the end of 1994, according to the NEC display group.

On the other hand, Sharp, the largest manufacturer of liquid crystal displays, is adopting a 360 x 465mm<sup>2</sup> size at its NF3 plant. Although there is no problem at present with regard to producing the 21cm diagonal size (8.4 type), Sharp is also examining the possibility of using 500 x 600mm<sup>2</sup> glass size at its Mie Plant, which is to go into operation July 1995. With this size, six of the 26cm panels and nine of the 21cm panels can be obtained from one substrate.

Sharp feels quite confident that flexibility is the answer to dealing with the mother glass substrate sizes. Sharp's strategy of aiming to supply panels of various sizes at the lowest cost possible to an unspecified number of

customers can be well understood. Since the optimum panel size for use in PCs, notebook type, and sub-notebook type computers differs, a 10cm diagonal (type 4) and 7.6cm diagonal (type 3) panel must be manufactured on the same production line for use in consumer equipment such as the [Viewcomm]. On top of this, it is also becoming necessary to allow for larger size in the glass peripheral area in conjunction with the high-pin driver LSIs which are needed to cost reduction. Amid these circumstances, Sharp considers it impossible to limit the glass size to one type. It is already making accommodations for slight differences in glass size in the vicinity of 360 x 465mm<sup>2</sup>, at its NF3 plant.

On the other hand, Display Technologies Inc. (DTI), which is a joint venture between Japan IBM and Toshiba, is adopting method (2) to obtain four panels per substrate. Four 10.1 type panels can be obtained using a 360 x 465mm<sup>2</sup> glass substrate. DTI is also examining the possibility of removing the outer leads on one side for driver applications to obtain four panels 26cm diagonal in size.

#### CVD Equipment Limits Panel Size

The CVD equipment for TFT processing is what limits the size of the glass substrate.

Applied Komatsu Technology's tray-type CVD device AKT-1600, which has taken the lead in second-phase

**Table 1. Possibilities Associated with Various Glass Sizes for 26cm Diagonal Panels, Four per Substrate**

The margins for glass sizes 360 x 465mm<sup>2</sup>, 370 x 470mm<sup>2</sup>, and 380 x 480mm<sup>2</sup> were calculated for 26cm panels, four per substrate. Assuming the CVD does not produce uniform film at a distance of 17-18mm from the edge of the glass, production is difficult with the 360 x 465mm<sup>2</sup> glass size. Four panels can barely be obtained using 370 x 470mm<sup>2</sup> glass size.

Panel Size			Mother Glass Size	Panel							Mother Glass Cutting Margin			Panel plus Cutting Margin	Margin to TFT Array	Possibility of Production	
				Light Shielding Section			OLB Section			Panel Total						When non-uniform film growth is 15mm from edge	When non-uniform film growth is 20mm from edge
				Di-mensions needed	Loca-tions needed	Total	Di-mensions needed	Loca-tions needed	Total		Di-men-sions needed	Loca-tions needed	Total				
Diagonal (cm)	Side	(mm)	(mm)	(mm)		(mm)	(mm)		(mm)	(mm)	(mm)		(mm)	(mm)	(mm)		
26 [10.4 type]	Short side	158.5	360	4	2	8	3	2	6	345.0	4	1	4	349.0	12.5	X	X
	Long side	211.3	465	4	2	8	3	1	3	444.7	4	1	4	448.7	13.7		
26 [10.4 type]	Short side	158.5	370	4	2	8	3	2	6	345.0	4	1	4	349.0	17.5	O	X
	Long side	211.3	470	4	2	8	3	1	3	444.7	4	1	4	448.7	16.2		
26 [10.4 type]	Short side	158.5	380	4	2	8	3	2	6	345.0	4	1	4	349.0	22.5	O	O
	Long side	211.3	480	4	2	8	3	1	3	444.7	4	1	4	21.2			
Approx 25 [10.1 type]	Short side	153.9	360	4	2	8	3	2	6	335.8	4	1	4	339.8	17.1	O	X
	Long side	205.2	465	4	2	8	3	1	3	432.5	4	1	4	436.5	19.8		

production lines, can basically accommodate only 360 x 465mm<sup>2</sup> substrate size, according to an engineer from a major panel manufacturing company. However, Tokyo Electron and International Electric, which entered the market later, produce tray-type CVD equipment which can handle sizes of 370 x 470mm<sup>2</sup> and larger. Nichiden Anelba produces an in-line type device, so small variations in glass substrate size can be accommodated.

Sharp and Toshiba, which have chosen the AKT equipment, will produce panels using 360 x 465mm<sup>2</sup> substrates for the time being. NEC, which has chosen the in-line equipment could immediately use the 370 x 470mm<sup>2</sup> size in production, but instead is using 360 x 465mm<sup>2</sup> substrates at its Kagoshima plant, where 24cm panels are top priority. NEC will select equipment for 370 x 470mm<sup>2</sup> substrates at its Akita plant. Hitachi uses equipment made by an associated company called International Electric, and foresees no problem in using 370 x 470mm<sup>2</sup> and larger substrates.

In view of the positions taken by the panel manufacturing companies, even Tetsuo Iwasaki, President of

AKT, who has said that the substrate size will not increase in the near future, acknowledges that there are many indications that equipment which handle 370 x 470mm<sup>2</sup> glass sizes are inevitable during 1994, as claimed by a competitor. Although AKT avoids making a definite statement, there are also those who feel that the glass size will be expanded to about 380 x 480mm<sup>2</sup>.

#### Patent Office Begins Reform of Industrial Intellectual Property Right System

94FE0578B Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 16 Mar 94 p 1

[Text] The Ministry of International Trade and Industry (MITI) and the Patent Office have started work on reforming the industrial property system, in order to tie the agreements of the New Round (New Round of Trade Negotiations) Intellectual Property (TRIP) negotiations, which concluded in December 1993, to the domestic system. The primary details revisions include strengthening requirements for establishing arbitration of patent

rights (mandatory patent rights) related to use of inventions, and removing nuclear inventions from the list of patent denials; these measures will greatly strengthen the position of those holding the rights. The reforms will be submitted to the Industrial Property Council in June and brought before a special session of the Diet this fall, with enforcement planned for January 1995. But because bills related to the New Round can be passed as a package proposal, the implementation of the law is expected to proceed while observing all legal measures.

The formal signing of the New Round draft agreement will take place in Marrakesh, Morocco on 15 April, and is expected to go into effect in January 1995. The current reform of the industrial property system is intended to be connected with the agreement.

The point of reform is to enable criminal and civil prosecution of proposals to sell copies of patented products as an act of patent infringement. Currently, a simple proposal was not subject to penalty. Utility models, designs, and trademarks will also be collectively revised.

In terms of mandatory patent rights, conditions for establishing arbitration of patent rights related to use of inventions will be strict. Use of inventions means inventions where, in order to patent one's own invention, another person's previously patented invention must be utilized; the current reforms will add restrictions so that these are "limited to cases targeting revision of non-commercial and non-competitive practices" as a requirement for establishing mandatory patent rights, particularly in the field of semiconductors. A judicial or administrative body will impartially judge whether or not the conditions are met.

Furthermore, the TRIP mutual agreement "enabling patent applications for technologies that can be used in industry, whether product or manufacturing process" will be accepted, and "substances that should be manufactured through nuclear conversion methods" will be removed from a list of reasons for patent denial. The reason that inventions in this field were not patented was that Japan's technological level was low, and there were fears of technological dominance by foreign enterprises. The reason for denying patents was simply a departure from good public custom.

According to Patent Office definition, items such as positron tracers, which are used to diagnose positron gaps, fall under the category of "substances manufactured through nuclear conversion". Apart from patents, the region of origin for wine and spirits are protected as "geographic indicators", and registration of trademarks that include the indicators are excluded for items such as scotch whiskey.

#### **MITI Proposes Plan for Use of Intellectual Property Right for Software**

94FE0578A Tokyo NIHON KEIZAI SHIMBUN  
in Japanese 23 Feb 94 p 1

[Text] In order to stimulate development of multimedia, which is expected to play a leading role in the information industry, the Ministry of International Trade and

Industry (MITI) has proposed new rules for the use of software copyrights for multimedia. The proposal will influence the Agency of Cultural Affairs' revisions of the Copyright Act, and the contents include establishing a "Digital Information Center" which will collect and administer the copyrights for graphics and sounds, and where software manufacturers can freely reproduce and process materials registered at the Center simply by paying a fee. In the past, software manufacturers had to obtain permission to use the rights from a number of authors, which required a lot of effort. If this concept is realized, the foundation for the spread of multimedia will be laid.

Multimedia takes existing software of music, pictures, and so forth, and freely processes or alters these with a computer. For example, the colors of an image can be changed, or another image can be put onto it, creating a product that differs from the original software in terms of impression or function. But multimedia's definition is not yet fixed, enabling it to be used in many more ways with future technological advances.

However, the copyrights for the music and graphics which are the materials for multimedia are protected, and software manufacturers must obtain permission before using these materials. And because one of the features of multimedia software is that it is created from a combination of materials from various authors, a great deal of time and money is spent on finding all of the authors and individual negotiations for royalties.

MITI's proposal allows authors to voluntarily register their copyrights at the Digital Information Center, and prospective users can go to the Center for a list of materials that can be used and to find out about royalties. Because the Center compensates the author with the fees paid by the user, the trouble of finding individual authors is eliminated.

In addition, revisions are being sought for the existing Copyright Act, which forbids alteration and processing of material so that it differs from the author's original meaning. In concrete terms, this will allow free alteration or processing as long as the contents do not injure the author's reputation; if the author is discredited, a court-ordered ban will be declared for a set period of time.

The other leading advanced nations are also having difficulties in dealing with multimedia copyrights, and in the United States, the establishment of an organization for collecting and administering copyrights, which closely resembles MITI's proposal, has surfaced.

But it is uncertain whether or not the Agency of Cultural Affairs, which is examining the need for a revised Copyrights Act, and the Copyright Council will accept MITI's proposal as is.

#### **This is the World's Largest TFT Production Base**

94FE0569A Tokyo NIKKEI MICRODEVICES  
in Japanese Feb 94 p 17

[Text]

### 2.5 Times Current Production Capacity Will Overwhelm Competitors

The newest and most modern plant rising above the ground in one corner of a huge site (Figures 1 and 2, not reproduced)—this is the picture of what Sharp's TFT (thin-film transistor) color liquid crystal plant should look like when it is completed. Sharp started construction of the plant in the Taki District of Mie Prefecture and plans to put it into operation in July 1995. That one-building plant alone will be the "world's largest-scale plant," says Haruo Tsuji, president of the Sharp Corp. Ultimately, the plant will produce 2.5 times the current monthly volume of 300,000 panels, when calculated in terms of 25-cm (10-inch) diagonal panels.<sup>Note 1)</sup> There is enough room at the site for three more buildings of the same size. Confident about Sharp being at the top of the industry, Mr. Tsuji says that "(if we can come this far), then [an increased] share [of the market] will result."

Sharp initially planned to invest ¥40 billion in the facility, but because of the sudden increase in demand [for TFT panels], the building's total floor space was doubled, and the amount of the investment grew to ¥53 billion. With only that initial investment the plant will have the capacity to produce 150,000 panels per month, even with allowances made for yield. Sharp aims to start production in July 1995 so that the amount of FY95 (March 1996 term) production will be ¥50 billion.

To make such large-scale production efficient, Sharp will introduce a CIM (computer-integrated manufacturing) system throughout the plant. Also, all processes except for some inspections will be automated to save time. That will result in productivity "three times that of the Tenri No. 1 plant and about 1.7 times that of the Tenri No. 2 plant," says Yasu Nishimura, assistant head of Sharp's liquid crystal project headquarters. Mr. Nishimura also says that the number of workers at the new plant will be "less than half the number at the Tenri No. 2 plant."

Sharp is now taking into account throughput, operation rate, and so forth in serious discussions about the dimensions of the mother glass substrate. "From 360 x 465 mm<sup>2</sup> to a maximum size of 500 x 600 mm<sup>2</sup>," says Mr. Nishimura. A decision will be reached by March.

#### Figure 1. Overall View of Sharp's Mie Plant.

The site covers 344,000 m<sup>2</sup>, which is enough space for four buildings the size of the facility for the first-stage production line. According to the data made public on 13 January, "this production line will start up in July 1995, its capacity will be 150,000 panels per month during the first year (FY1995), and the yen-valued amount of production for the first year (FY1995) will be ¥50 billion." Sharp says that it will raise the level of production in stages and did not comment on the unit price, but a simple calculation based on the foregoing data gives a unit price of about ¥37,000 for a 10-inch panel.

#### Figure 2. Expected Appearance of Mie Plant's First-Stage Production Line When it is Completed.

The building will be 168 x 80 x 20 m<sup>3</sup>, and the total floor area will be 56,191 m<sup>2</sup>. Construction started in January 1994 and should be finished by January 1995. The plant section has three floors. The clean area will be on the top floor and will cover 5,000 - 6,000 m<sup>2</sup> plant will be 10.4-inch VGA- and higher-class high-quality full-color panels, all of which will employ wide-field-of-vision technology.

Note 1: Sharp converted the total area of the panels it shipped into the number of 25-cm (10-inch) diagonal panels into which the total area can be divided, then consolidated that with the value of expected yield. The current production volume is 120,000 panels per month from the No. 1 Tenri plant that is in operation (the No. 2 plant will start contributing in May). The eventual capacity of 300,000 panels per month at the Mie Prefecture plant's first production line will be 2.5 times the volume of the No. 1 Tenri plant. However, 150,000 panels per month will cover the initial investment in the first-stage production line, which will go into operation in July 1995.

### Toshiba Reduces Cost of MCMs through Semi-Custom Method

94FE0222 Tokyo NIKKEI ELECTRONICS  
in Japanese 6 Dec 93 pp 165-178

[Text] Toshiba Corp. will begin taking orders for two semi-custom multi-chip module (MCM) products in 1994. The semi-custom methods that have been cultivated in gate array and cell-base LSIs have been introduced into MCMs, and this makes for a reduction in costs and a shortening in the development period. The MCM-C product, which has a ceramic board, can easily compete with normal custom epoxy printed circuit boards. This is aimed at the next generation of game machines and high-end consumer products. The other product is the high performance MCM-D/C, and it is aimed at work stations and the like. Using an EDA system that is on the market, customers can design either product themselves.

The operating speeds, packaging density and reliability requirements for systems are growing each year. It has been known for a long time that multi-chip modules (MCMs) are an effective means for helping meet these. However, actual applications of MCMs have been extremely limited to ones like large computers and military electronics.

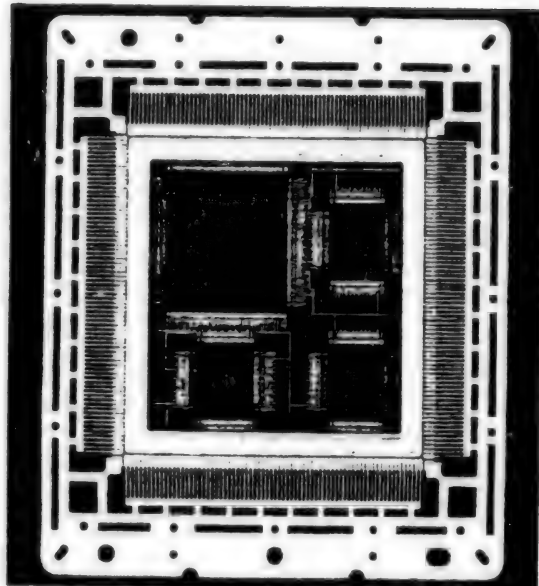
The reason is that MCMs were naturally developed as fully custom systems. If we start with basic operations such as the selection of board materials, a development period of at least 5-6 months is necessary, and the costs are high at ¥10,000,000 or more. This has not been a level that can be used in common electronic equipment.

#### MCMs That Can Be Used in Common Electronic Equipment

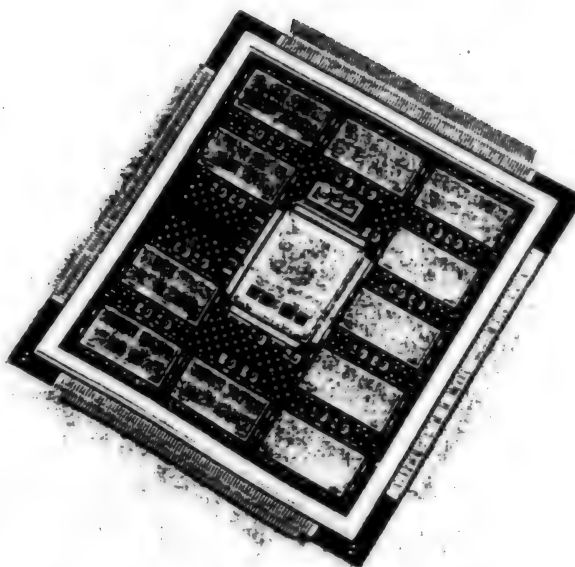
These MCM problems can be solved by using the semi-custom methods that have been employed for gate arrays

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(a)



(b)



The New Semi-Custom MCM Products: Two products have been prepared, the TAM10C series (a), which is the MCM-C type, and the TAM10Z series (b), which is the MCM-D/C type. The (a) TAM10C series is enclosed in a  $40 \times 40 \text{ mm}^2$  ceramic flat package. There are 288 external pins. The pin pitch is 0.5mm. It is equipped with one 0.8 $\mu$  gate array TC160G series U2 (120,000 usable gates) and two U54s from the same series (22,000 gates). The total number of gates the module is equipped with is 186,000. This MCM is a characteristic checking test module. (b) is an example of the TAM10Z series. It is enclosed in a ceramic flat case with dimensions of  $64 \times 64 \text{ mm}^2$ . There are 348 external pins. The pin pitch is 0.5mm. The center chip is an R4000 RISC processor. The clock speed is 50MHz. The 11 chips on the outside are 1M bit SRAMs.

and cell-base LSIs. Toshiba has marketed semi-custom MCMs for which the board size and design rules and the development processes have been standardized. By introducing semi-custom development methods, we have greatly reduced costs.

First of all, orders will be taken for two products starting in 1994. One product is the TAM10C series in which low cost is pursued while maintaining a certain performance. It is aimed at the next generation of game machines and high-end consumer products (photo (a)). This series is an MCM-C with a simultaneously fired ceramic board.

The other product is the TAM10Z which maintains the performance of full-custom methods while containing costs. It is mainly aimed at high-performance electronic equipment such as work stations (photo (b)). This is an MCM-D/C equipped with an MCM-D in which a Cu/polyimide multi-layer interconnect layer is formed on the MCM-C board.

At present, the solder mounted parts are Toshiba gate arrays, cell-base LSIs and embedded array ASICs. We have RISC microprocessors and peripheral LSIs for the TAM10Z.

Using chips from other companies is very difficult at present. There are quality problems, such as no established method for bare chip evaluation. Furthermore, solutions must be found for nontechnical items such as open information and contracts for maintaining secrets between MCM makers and chip suppliers. It can be assumed that when MCMs become popular for common electronic equipment, rules will be established for these points.

#### Costs Competitive with Printed Circuit Boards.

We will give a detailed discussion of the semi-customization technology put into these products later, but first we will give a concrete introduction to the cost reduction and reduction in development period that results from it. There are many types of MCMs that vary in structural materials, characteristics and cost, but here we will use ceramic board MCM-Cs as an example (see "Optimal MCMs for Large-Scale Systems"). We will compare conventional full-custom MCMs and the new semi-custom MCMs as well as glass/epoxy resin printed circuit boards.

First of all is the case of developing a full-custom MCM-C. The module unit cost is ¥ 50,000 to 100,000,

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and the development period is probably five months (in the case of using four soldered gate arrays with 50,000 gates and a 300 pin ceramic package, exclusive of the gate array cost, development funds and development period).

If this company's TAM10C series, which is a semi-custom MCM-C, is used, the module unit cost is 50-80% of that for a full-custom unit and the development costs and development time can be reduced by half. In terms of development time, technology for reducing it to four weeks is being developed.

The fact that the module unit cost is lower than that for full-custom ones deserves special mention. This differs from the case of single-chip LSIs. With single-chip LSIs, the Si surface area has an effect on the unit cost, and in most cases, full-custom LSIs have had lower unit costs than semi-custom ones. On the other hand, since the structure of MCMs is complex, the test costs have a large effect on unit costs. Because of this, the unit cost of

semi-custom products, in which the test processes have been standardized, are lower than for full-custom modules.

Now, let us compare the TAM10C series with normal printed circuit boards (Table 1). Let the four identical gate arrays be soldered to a four layer glass/epoxy printed circuit board. The developmental costs and development period for the printed circuit board are much better. Those for the printed circuit board are about half of those for the TAM10C series.

The total costs (unit costs), which take into consideration the package cost, etc., are well matched. If we assume that the package is a ceramic package, the TAM10C is less expensive. In terms of solder-board area, the MCM has a great advantage. Furthermore, if we consider the fact that reliability, thermal characteristics, signal quality (transmission line characteristics) are improved, the MCM can easily compete with printed circuit boards.

Table 1 Comparison of the New Semi-Custom MCM with Printed Circuit Boards<sup>\*1</sup>

	TAM10C series (MCM-C)	Printed circuit board (glass/epoxy resin)	
		gate arrays in ceramic QFPs	gate arrays in plastic QFPs
Unit cost (total cost) <sup>*2</sup>	100	110	80
Development costs <sup>*3</sup>	100	50	50
Development period	100	50	50
soldering surface area of printed circuit board	100	500-1000	500-1000

<sup>\*1</sup>Equivalent value when that for the TAM10C series is 100. Both the TAM10C series and the printed circuit board are equipped with four gate arrays of 50,000 gate scale.

<sup>\*2</sup>Unit cost is the packaged TAM10C series. The printed circuit board is the total of the packages for the gate arrays and the cost of the printed circuit board. The unit costs and development costs of the gate arrays are not included.

<sup>\*3</sup>Development costs for gate arrays not included.

### Large Cost Reduction Even for High-Performance Products

Next, we will clarify the effects of the semi-customization of the high-performance TAM10Z series. Here we will make a comparison with a full-custom MCM. We will not make a comparison with a normal printed circuit board. There is a large difference in the performance that can be realized between the MCM and a printed circuit board, and the comparison would basically be meaningless. First is the case of full-custom development. With the MCM- C/D type, thin film processing for layering polyimide films on an MCM-C board is necessary. Because of this, there is an increase in development time and development costs over the full-custom MCM-C. The development period is at least five months or more, and the development costs are 10,000,000-20,000,000 or more. With the semi-custom TAM10Z series, the outlook is that the development costs and development period will be reduced to about 1/2 to 1/3 of those for the full custom module. However, the unit cost of the TAM10Z series is about ten times that of that of the TAM10C series with the same soldered circuit.

When examining whether or not to make MCMs for a system, the unit cost, the development cost and the development period are important, but in addition to these, we must consider it from different angles, such as (1) operating speed, (2) heat countermeasures, (3) reliability, (4) number of input and output pins, (5) package dimensions and (6) soldering density.

### Semi-Customization Technology (Hardware): Standardization of Module Structure and Cost Containment

With the advent of ASICs such as gate arrays and cell-base LSIs, single-chip custom LSIs came into wide use in electronic equipment. With the standardization of chip structure for ASICs, there was success in reducing the development period and the development costs from the customer's point of view. Furthermore, by making design possible with the EDA systems on the market, it has become possible for customers to add to ASIC designs. If design can be done on the customer side, design time and cost can be held down.

The semi-custom MCMs marketed this time are ones bring in these methods which were cultivated with

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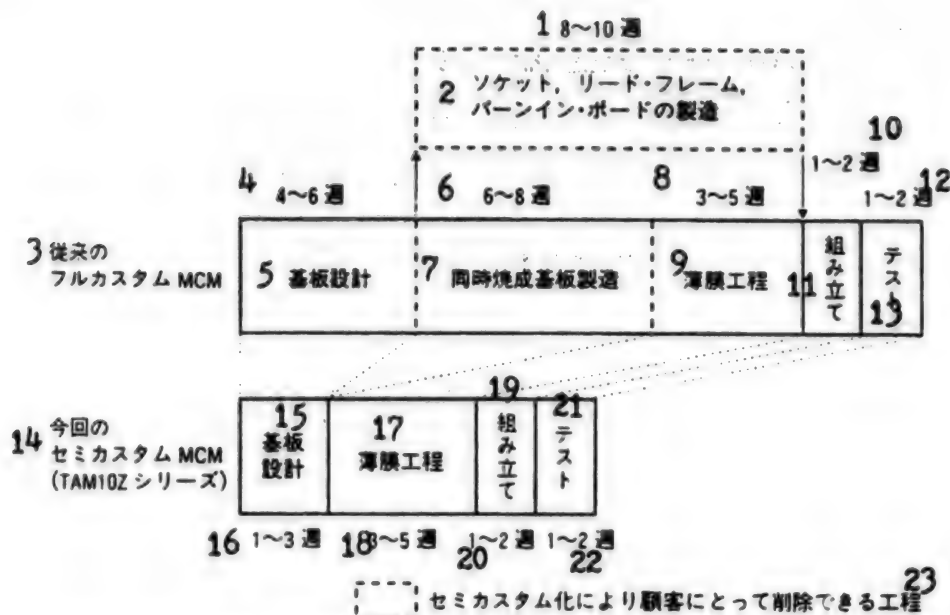


Figure 1. Reduction of Development Period through Semi-Customization: TAM10Z series. The design period (board definition and chip position and lines) is about half. In addition, just as with master wafers for gate arrays, the MCM-C portion is produced in advance of customer orders, so the development time for the customer is greatly shortened.

Key: 1. 8-10 weeks; 2. sockets, lead frame, burn-in board production; 3. conventional full-custom MCM; 4. 4-6 weeks; 5. board design; 6. 6-8 weeks; 7. simultaneous firing board production; 8. 3-5 weeks; 9. thin film processing; 10. 1-2 weeks; 11. assembly; 12. 1-2 weeks; 13. testing; 14. new semi-custom MCM (TAM10Z series); 15. board design; 16. 1-3 weeks; 17. thin film processing; 18. 3-5 weeks; 19. assembly; 20. 1-2 weeks; 21. testing; 22. 1-2 weeks; 23. what can be eliminated for the customer with semi-customization

ASICs. In comparison with full-custom MCMs, the development period is shortened and the development cost greatly reduced. In addition, the module unit cost is lower with this semi-custom MCM.

#### Board Development Period Halved

We will use an example of the TAM10Z series to take a detailed look at the reduction of the development period with semi-customization (Figure 1). First, there is the board development period. This is about one-half. This is because there is a standard board, and the data (library), etc., for design rules and analysis tools is already available. The difference from full-custom is that work can immediately be started on actual design.

As will be discussed later, the ceramic board which forms the foundation (the MCM-C portion) is produced in advance. Because of this, the development time for the customer does not include the production time for the simultaneous firing part. Furthermore, development of sockets and test jigs, which is carried out in parallel with the production of the MCM-C part in the full-custom case, is done without waiting for customer orders.

Next, there is the reason that development costs can be reduced. As in the above, the sockets and test jigs can be used in common for a number of customers. With this, the cost per customer is reduced. In addition, the reductions in personnel costs that go along with the shortening of the development period have an added effect on the reduction of development costs.

Furthermore, as another merit of semi-customization for the customer, we can bring up the following point. That is, the effectiveness of using MCMs can be examined on the level of planning set products. If the main specifications of the MCM are determined, it is easy to estimate the final form, development costs, unit cost and development time. Whether or not MCMs should be used can be determined rapidly.

#### Preparation of Two Products Aimed at Price and Performance

This company has marketed two series of MCMs with the these merits of semi-customization. One places importance on low cost and the other on high performance.

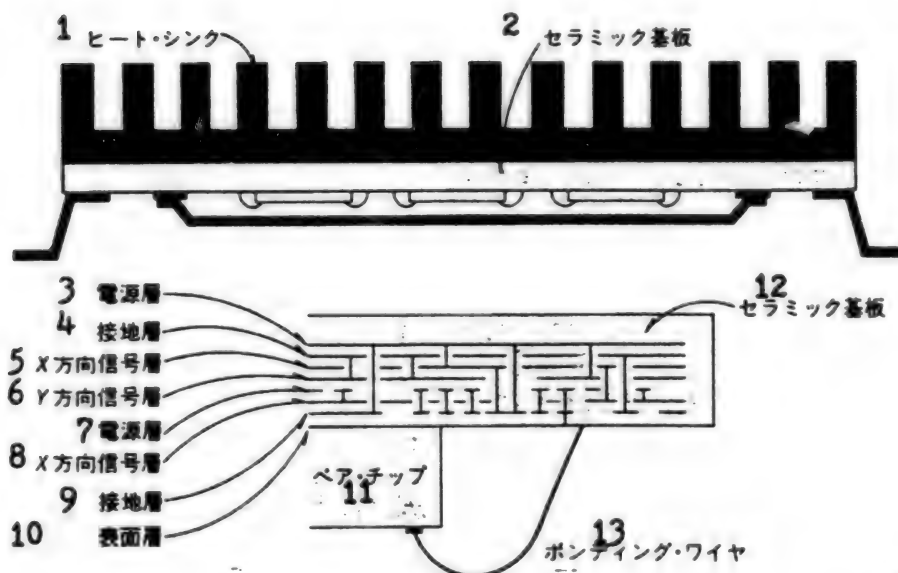


Figure 2. Structure of TAM10C Series: MCM-C technology is used. This is the case in which multiple chips are enclosed in a flat package. There are total of seven layers in the ceramic board, the signal, power supply and ground layers. Connections with the chips are wire bonding. When the power consumption of the chips included is small, the heat sink is unnecessary.

Key: 1. heat sink; 2. ceramic board; 3. power supply layer; 4. ground layer; 5. X-direction signal layer; 6. Y-direction signal layer; 7. X-direction signal layer; 9. ground layer; 10. surface layer; 11. bare chip; 12. ceramic board; 13. bonding wire

The one that places importance on low cost is the TAM10C series. It was developed with consciousness of being able to stand up to the low cost of MCM-L. Because of this, an MCM-C that uses the simultaneous firing technology that was cultivated for LSI packages was chosen (Figure 2).

There are various types of standardization with the TAM10C series (Table 2). First of all, the module dimensions match EIAJ standards (Table 3). Concretely, there are four sizes, from 32 x 32 mm<sup>2</sup> to 56 x 56 mm<sup>2</sup>. The reason that nothing very large is prepared is that it is aimed at the level of mounting four gate arrays at present (Figure 3).

Table 2 Items Standardized for the TAM10C Series

Standardized item	Items with commonality due to standardization
dimensions	lead frame
number of external pins	heat sink
lead pitch	carrier, sockets
	package lid
	test jigs

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Table 3 New Product Dimensions, Lead Pitch and Number of External Pins<sup>note</sup> (QFP configuration)

		lead pitch			
		1.0	0.8	0.65	0.5
dimensions (mm <sup>2</sup> , EIAJ standards)	32 x 32	116 pin	144 pin	176 pin*	224 pin*
	40 x 40	144 pin	184 pin	224 pin*	288 pin*
	48 x 48	176 pin	224 pin	272 pin**	360 pin+
	56 x 56	184 pin	232 pin	280 pin**	368 pin+
	64 x 64	216 pin	272 pin	328 pin+	432 pin+
	80 x 80	280 pin	352 pin+	432 pin+	560 pin
	96 x 96	344 pin	432 pin+	528 pin+	688 pin
	112 x 112	408 pin	512 pin	624 pin	816 pin
	132 x 132	488 pin	608 pin	752 pin	—
	152 x 152	568 pin	712 pin	—	—

note) Figures in the table are number of external pins. \*TAM10C series, \*\*both, +TAM10Z series

It was set up so that four pin pitches could be chosen for each set of module dimensions. In other words, there are two (0.5mm and 0.65mm pitches) for the QFP configurations and two (70mil (approx. 1.78mm) and 50mil (approx. 1.27mm)) for the PGA configurations. This means that the customer chooses the board size and number of pins from the scale of the circuit and the number of signals in the system to be constructed.

Besides this, the sockets, test jigs and heat sinks have been made common for each standard module board.

#### Coverage up to Supercomputers

The other product is the TAM10Z series, which goes after performance (Figure 4). It covers everything from high-performance work stations to supercomputers. The MCM-D/C structure combines MCM-D, which has excellent electrical characteristics, with MCM-C.

In addition to the standardization methods introduced in the TAM10C series, the method of producing part of the module before customer orders, as with gate arrays, was employed with the TAM10Z series, and this

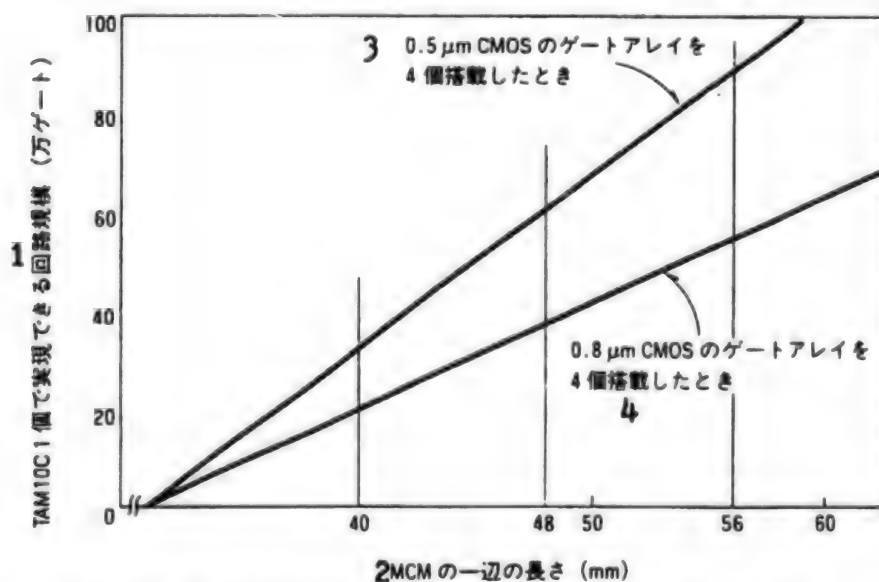
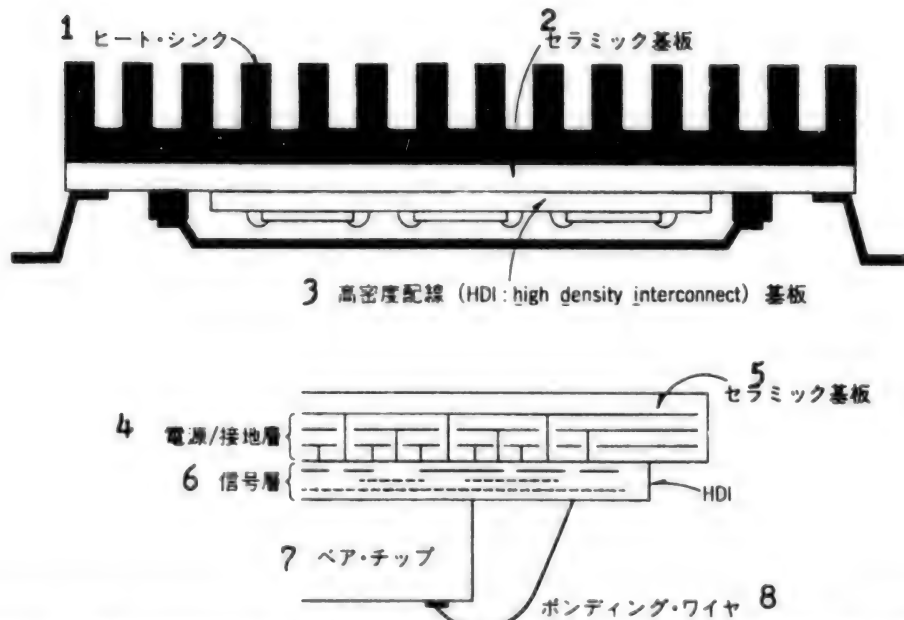


Figure 3. Circuit Scale for One Module in the TAM10C Series: when equipped with four Toshiba 0.5μm CMOS gate arrays and four 0.8μm gate arrays

Key: 1. Circuit scale possible with one TAM10C (10,000 gates); 2. Length of one side of MCM (mm); 3. when equipped with four 0.5μm CMOS gate arrays; 4. when equipped with four 0.8μm CMOS gate arrays

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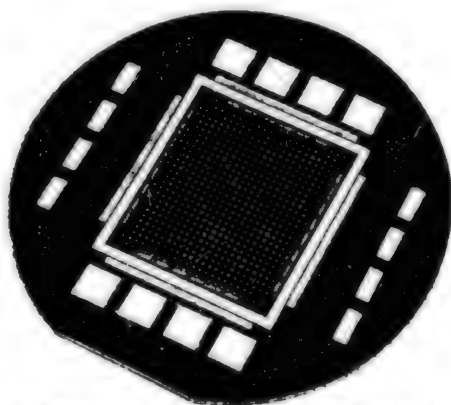


**Figure 4. TAM10Z Series Structure:** MCM-D/C technology is used. This is the case when multiple chips are encased in a flat package. The ceramic board contains the power supply layer, and is produced before customer orders. This is the same idea as for the master wafers for gate arrays. As with the metal lines in gate arrays, the signal layer is created for each customer. Cu thin film lines are used in this MCM. Chip connections are by wire bonding. When the power consumed by the chip is small, the heat sink is unnecessary.

Key: 1. heat sink; 2. ceramic board; 3. high density interconnect (HDI); 4. power supply/ground layers; 5. ceramic board; 6. signal layers; 7. bare chip; 8. bonding wire

shortens the development time for the customer. In other words, The MCM-C part is produced ahead of time like the master wafers for gate arrays (Figure 5).

Two power supply layers and one ground layer are included in the ceramic board. Bia [lateral] holes, sealing and brazing pads are set on the surface layer in standard positions. Several outer leads are fixed as power supply



**Figure 5. TAM10Z Series Simultaneously Fired Board:** State prior to customer orders. It corresponds to the master wafer for gate arrays.

leads, and the power supply system is strengthened by connecting them directly to the internal power supply layer.

As with the metal distribution lines of gate arrays, the MCM-D part is customized for each customer.

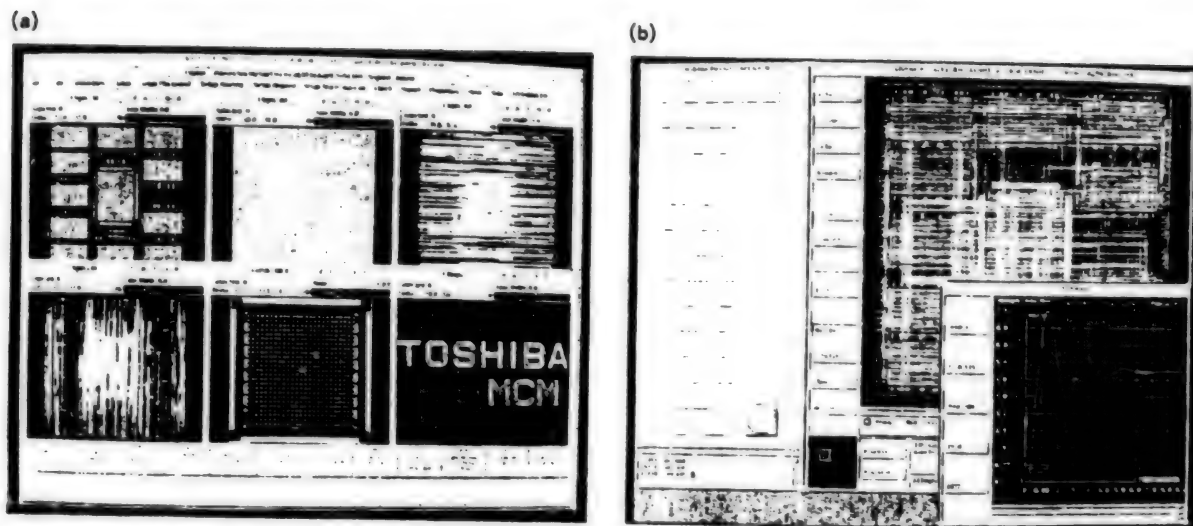
This is made up of conductive layers, the mesh layer for impedance control, the X and Y distribution line layers used for the signal lines, and the surface Cu. Polyimide is used for the insulator film.

#### **Semi-Customization Technology (Software): Construction of an EDA System that Set Developers Can Use**

In addition to semi-customizing the module structure, we semi-customized the design and development system. In other words, we made it so the MCM maker and the set maker, who is the user, could divide the design work. The key to this is a development environment based on EDA systems that are on the market. Without this, half of the merit of semi-customizing the module structure would be lost. This time, we constructed a semi-custom MCM design system jointly with EDA vendors.

#### **ASIC Development Methods as a Model**

The aim in constructing the system was creating an EDA system that could be handled by set developers who were



**Figure 6.** The Newly Constructed MCM Development Environment: Toshiba's design kit was incorporated into EDA systems already on the market. The base for (a) is MCM Station from Mentor Graphics Corp. of the U.S.A.. The various design data to be turned over to the production process after the completion of the MCM design are shown. The windows from the upper left are pad layer, ground layer, X-direction signal layer, and skipping one, the simultaneous firing board data and the Y-direction signal layer. The base for (b) is Allegro MCM from Cadence Design Systems, Inc. of the U.S.A. After the MCM distribution line design was completed, the transmission circuit analysis was carried out. The windows from the left are the menu, an example of the results for positions and distribution lines for the TAM10Z series (from (b) in the first photo) and the voltage waveform for one signal line.

not MCM experts. MCM design EDA systems are marketed by several EDA vendors, but unfortunately, they are aimed at MCM experts. In order to really popularize MCMs, there is a need for a structure that allows set developers to easily design them in a short time.

If we take a general view of the flow in MCM design, we can divide it into system design, board definition, positioning and distribution lines, and verification operations. These are similar to the development processes for ASICs. Therefore, this company used ASIC development methods as a model and constructed a semi-custom design environment. The features of ASIC development methods, which are familiar to most set designers, are the standard developmental flow and design tools and the fact that the library is arranged as a design kit. If the customer proceeds with the process following the manual, the design process can be completed. A design check is dictated at the end of each process, and it is set up so there is no design contravention. The second feature of the ASIC design method is that the customer can select the range of his design work according to his own wishes.

#### Joint Development with U.S. EDA Vendors

Concretely, semi-custom MCM customers will be supplied with MCM development systems from two U.S. EDA vendors into which a design kit developed by this company has been incorporated (Figure 6). The design kit is made up of this company's own point tools and

various kinds of data (library) for these point tools and the EDA vendors' point tools (Figure 7).

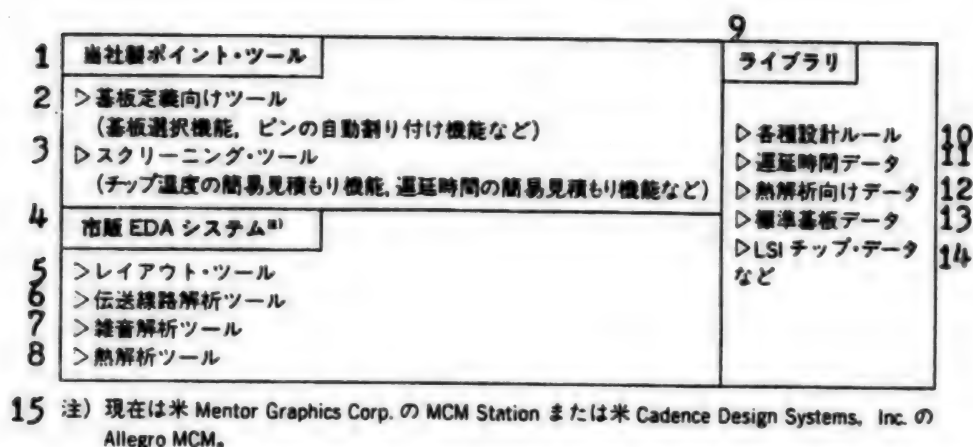
At present, we have two of our own point tools. One of them, the board definition tool, is a function for selecting the MCM product and standard board from a menu, and it includes a pin assignment function, etc.

The other Toshiba tool is used for design screening. There is an easy estimation function for chip temperature, which is particularly effective during initial design stages, and a function for easily estimating delay time using provisional distribution line lengths. General performance can be predicted without carrying out time-consuming detailed analyses. Furthermore, the simple estimation values are effective material for determining whether or not to do detailed analyses.

In addition to design rules and standard data necessary for distribution line design and chip data, the various parameters necessary for analytical tools, power consumption, buffer simulation models, package simulation models, etc. are recorded in the library. There is no need for the customer to re-input this data.

#### Simple Checks for Each Process

The development flow for semi-custom MCMs using these EDA systems is shown in Figure 8. Operations with an asterisk beside them make use of this company's own tool.



**Figure 7. Structure of Semi-Custom MCM Development system:** This is made up of EDA systems that are on the market and this company's own point tools and library. This company's point tools and library are called the design kit.

Key: 1. Toshiba point tools; 2. board definition tool (board selection function, function for automatic assignment of pins, etc.); 3. screening tools (function for easily estimating the chip temperature, function for easily estimating the delay time, etc.); 4. EDA system<sup>note)</sup>; 5. layout tools; 6. transmission circuit analysis tools; 7. noise analysis tools; 8. heat analysis tools; 9. library; 10. various design rules; 11. delay time data; 12. data for heat analysis; 13. standard board data; 14. LSI chip data, etc.; 15. Note) At present these are MCM Station from Mentor Graphics Corp. (U.S.A.) and Allegro MCM from Cadence Design Systems, Inc. (U.S.A.)

First is board definition. Considering performance and cost, either the MCM-C (TAM10C series) or MCM-D/C (TAM10Z) is selected. The design rule and layer structure are determined at this time. Next, the system design data (net list) is input, and the optimal size of board is selected from the standard board menu. A pin number chart, which is written in ASCII format, is input, and terminals are automatically assigned. At this time the minimum value for the number of power supply pins and the positioning of power supply pins, which are factors in power supply noise and package constraints are checked. With this board definition is completed. At this stage, the MCM chip temperature is estimated simply, and it is determined whether or not heat analysis or special heat sink design is necessary.

Next, the chips are positioned on the MCM. After positioning, a simple estimation of distribution line delay time is made, if necessary. Provisional distribution line lengths based on the positioning information are used for this. Performance can be predicted before the time-consuming distribution line design. In addition, this is material for determining whether special distribution line techniques are necessary for satisfactory performance. Then we move to the distribution line process. After the distribution lines are finished, delay time analysis and transmission circuit analysis (option) are carried out. If there is no problem here, the design is complete. It moves to production and testing.

With the preparation of tools for simply estimating chip temperature and delay time, the frequency of using time-consuming, detailed analysis tools can be reduced. In

addition, because check points are set up at various places in the process, it is possible to make delays in the design period small, even if redesign is necessary.

#### Customer Selection of Design Range

There are various different types of user-maker interface, the boundary of design division between the customer and the MCM maker, just as with ASICs, and we set it up so the customer could select the design range.

Basically MCMs are a means of maintaining circuit performance, and if customers with little experience do the design, it is difficult to extract good results. In terms of design constraints such as indication of critical path, there is a need for an intimate connection between the system designers and the layout personnel. On the other hand, if there is much experience in MCM design, there are cases in which the system designer's own layout design is more efficient.

As is shown in Figure 9, we have established level 1 through level 4 for the user-maker interface for these new MCMs. The interface level can be chosen according to the customer's requirements.

With level 1, in which the MCM maker's design responsibility is the greatest, the user only preparing the MCM specifications (planning information) and the pin position list. On the other hand, with level 4, the user performs all of the design and verification operations.

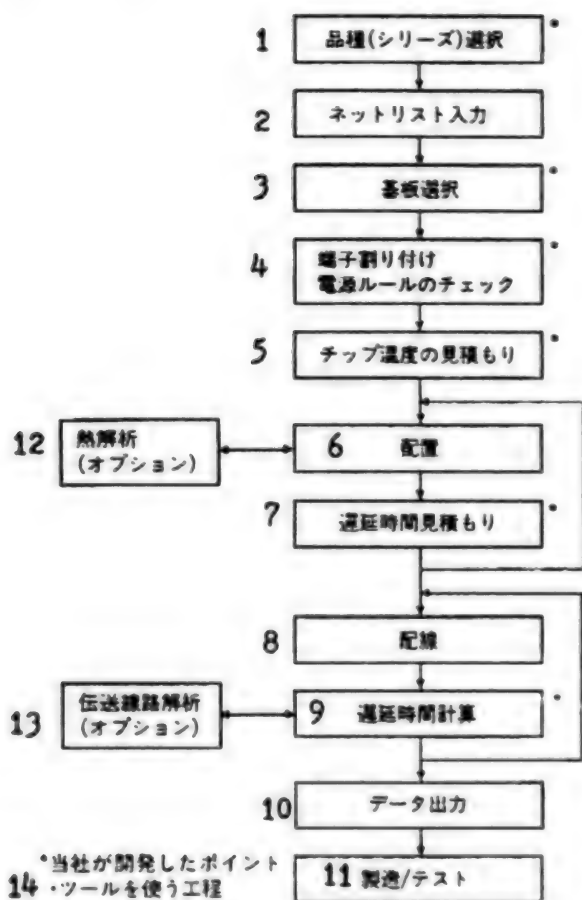


Figure 8. Semi-Custom MCM Development Flow: Points are set up for checking the design at each stage in the design. In this way the frequency of having to run optional functions that carry out detailed analysis is reduced, and it helps shorten the development period. An asterisk indicates a process that uses this company's point tools.

Key: 1. product (series) selection; 2. net list input; 3. board selection; 4. pin assignment, power supply rule check; 5. chip temperature estimation; 6. positioning; 7. delay time estimation; 8. distribution lines; 9. delay time computation; 10. data output; 11. production/test; 12. heat analysis (option); 13. distribution circuit analysis (option); 14. \*processes using the point tools developed by Toshiba

#### Problems Such as Establishment of Test Methods

With predictions such as "By the year 2000, 1/2 of LSIs will be mounted on MCMs" (Dataquest, Inc. (U.S.A.), 1991), MCMs are expected to be the next generation of mounting technology. However, there are still some problems that remain to be solved. Here we will discuss three of them, testing, large packages and system development environment.

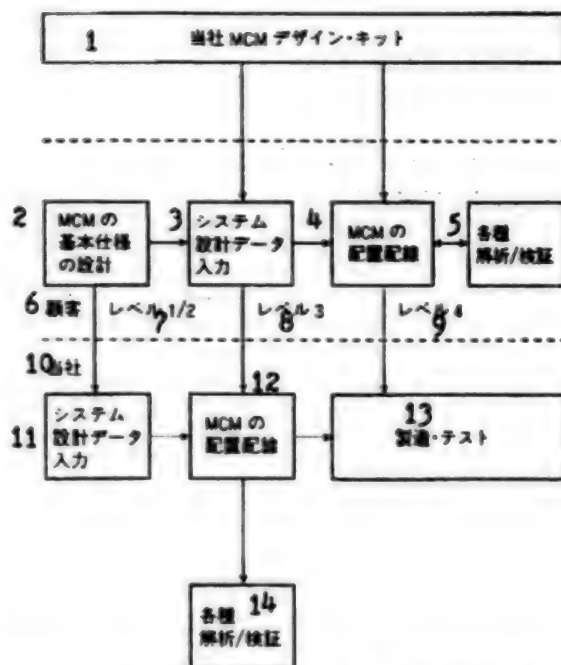


Figure 9. Variations in Customer Design Range: Just as with ASICs, there are various configurations for the division of design responsibility between the customer and the MCM maker. On level 1, the customer only prepares the basic specifications and pin position list for the MCM. On level 2, the customer prepares the information from level 1 and the information on internal connections in the module (net list). On level 3, everything in the design flow in Figure 8 before positioning is the responsibility of the customer. In other words, the customer defines the MCM board, and estimates the chip temperature. On level 4, the customer does everything. On levels 1, 2 and 3 this company takes responsibility for all detailed analysis (heat analysis, transmission circuit analysis and Noise analysis).

Key: 1. Toshiba MCM design kit; 2. design of basic MCM specifications; 3. system design data input; 4. MCM positioning and distribution lines; 5. analysis and verification; 6. customer; 7. level 1/2; 8. level 3; 9. level 4; 10. Toshiba; 11. system design data input; 12. MCM positioning and distribution lines; 13. production and testing; 14. analysis and verification

#### Expectations for Boundary Scan Testing

One of the main problems with MCMs is testing. Figure 10 shows the production and test flow for MCMs. Unfortunately, there are presently no efficient means for testing in the final configuration or bare chip testing.

In comparison with bare chip supply, testing of individual chips is easier if the chips are supplied encased in packages. Even after they are in their final form mounted on printed circuit boards, each part can be tested using in-circuit testers, and defective areas can easily be specified.

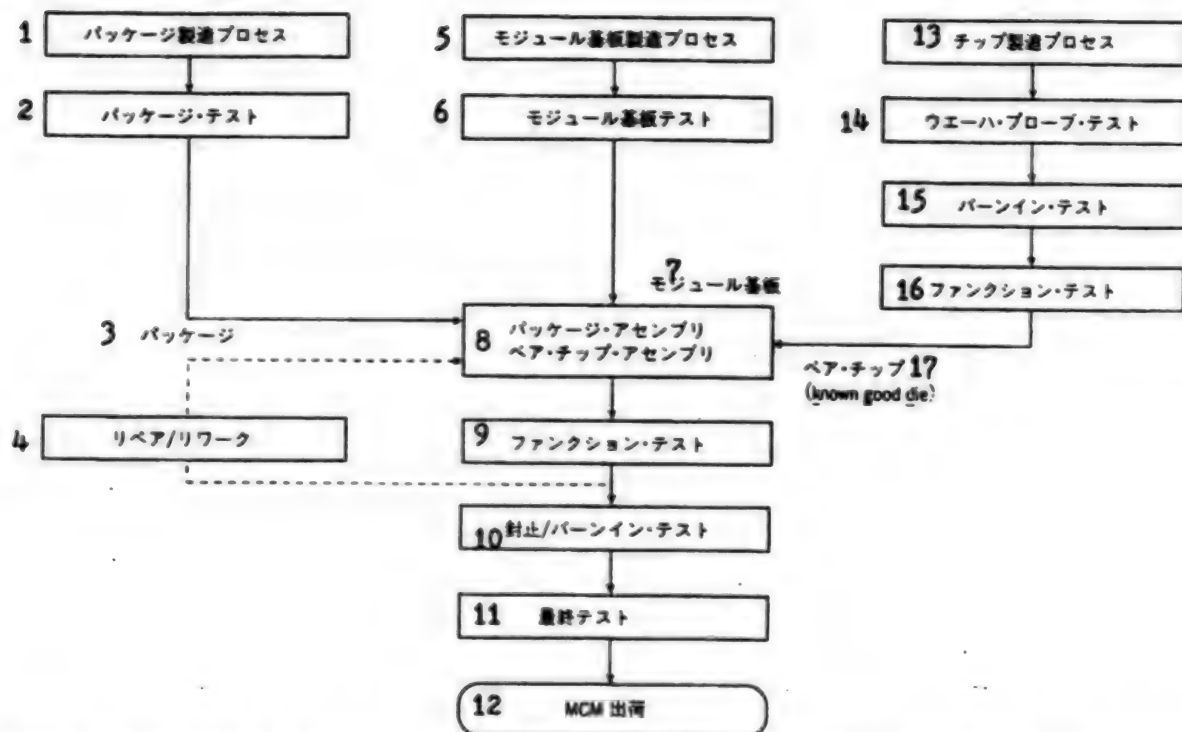


Figure 10. MCM Production Processes and Testing: The boards, chips and packages that make up MCMs are tested individually before assembly. If all are good, they are assembled. Before the MCM is encased in its package, total function tests are carried out, and after burn in tests final testing and AC/DC testing is done.

Key: 1. package production process; 2. package testing; 3. package; 4. repair/rework; 5. module board production process; 6. module board testing; 7. module board; 8. package assembly, bare chip assembly; 9. function testing; 10. sealing/burn-in testing; 11. final test; 12. MCM shipment; 13. chip production process; 14. wafer probe test; 15. burn-in testing; 16. function testing; 17. bare chip (good known die).

In contrast to this, with MCMs, there are the constraints of bare chip mounting and having to identify good and bad chips in the assembly indirectly from the limited external pins. Not only tests that avoid these constraints, but also high precision multi-pin testers for guaranteeing performance are indispensable.

As a means for specifying bad places, the method of using a boundary scan has been standardized as IEEE 1149.1 (JTAG). This is a method for being able to access all chips from the external pins of printed circuit boards and MCMs, and it is a very effective method for MCMs. However, all chips in MCMs and on printed circuit boards must be able to handle boundary scans (must have dedicated test pins and dedicated test circuits). If this condition is met, software that automatically generates the test pattern (ATPG) can be used. However, few chips can handle boundary scans at present. At present, they are limited to the most advanced microprocessors and a small number of ASICs. Most chips that were developed a little while ago, memory and general purpose ICs cannot handle boundary scans. The testing of MCMs that include chips that do not handle boundary scans in their final form is a major problem.

In order to solve the problem of how to get good chips (known good die (KGD)), the problem is bare chip handling and testing. This remains as an important theme for the MCM industry. We can see from the fact that bare chips are more costly than packaged ones just how difficult it is to solve this problem.

Since MCMs mix different kinds of chips, the establishment of reliability test conditions is difficult. It can be said that the completeness of an MCM is connected to just how far the chips can be guaranteed. There are still many problems to solve before chip histories, reliability, chip logical simulation models, buffer circuit simulation models and chip characteristics can be opened up for customers.

#### Large-Scale MCM Mounting an Unknown Area

There are problems in the packaging of completed MCMs and mounting them on printed circuit boards. There is no problem if the size of the MCM is between 40 x 40 mm<sup>2</sup> and 50 x 50 mm<sup>2</sup>. There is enough experience with single chip LSIs. However, if they are larger than

this, there are many unknowns, and there are still problems concerning packaging and mounting that remain to be solved.

The package configurations that have a high possibility of being carried through are summarized in Table 4. Considering mounting on mother boards, the surface mountings entail fewer processes overall. However, when large packages are surface mounted, lead skew and coplanarity are troublesome. Stress also needs attention.

Cavity-down types, to which heat sinks can easily be attached, are good in consideration of heat. However, the area for mounting chips is reduced, and the number of pins is fewer. We cannot obtain a solution that is totally satisfactory.

#### Chip Models Indispensable for System Design

The current MCM development environments, including the EDA systems developed this time, focus on positioning and distribution line design. If we want to develop MCMs in a short time, we must arrange an upstream system development environment. Within this, it is important to easily carry out verification of the logical function of the entire system.

Logical function simulators and chip simulation models for EDA tools are necessary in order to verify logical functions. Simulators have good records in the ASIC field, and it would be sufficient to use them.

The problem is chip simulation models. Function models for the main microprocessors and peripheral LSIs have started to come on the market, but arranging function models for all of the chips that are used in MCMs is unmanageable for a single MCM maker. It requires a large amount of time and effort. U.S. function model vendors carry out modeling services, but they are quite expensive.

For the present, we must probably get through with simulations that are made with existing gate level models, which are data from chips are developed. However, the verification is much longer than for function level simulations.

If the arrangement of chip function models makes progress, there will be a shift to function level simulations. At the earliest, it will probably be two or three years before function level simulations are carried out as a rule.

Besides this, we have hopes for floor planners that take into consideration chip partitioning, delay and test methods at the function level and commercialization of tools that can carry out system level logical synthesis.

The completion of these EDA tools is necessary for system design regardless of the presence or absence of MCMs. The confirmation of whether the system can carry out the desired functions at the earliest possible stage in development is a shortcut to reducing system development time.

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[Box, p 168-169]

#### Optimal MCMs for Large-Scale Systems

The ultimate configuration for electronic circuits is putting the entire circuit on a single chip. However, with current CMOS LSI production technology, custom LSIs with systems on the scale of 1,000,000 gates are not realistic. Taking gate arrays as an example, the predictions are that gate arrays that are equipped with circuits on the scale of several million gates will be marketed around 1997 (Table A-1). However, the speed of production technology has slowed down after coming this far. The facilities investment and introduction resources necessary for the change to the next generation of production technology is so large that the predictions are that we cannot keep going along the same line. This is where MCMs are significant. This is because, using existing LSI production technology, high density mounting technology and CAD technology, we can obtain a performance that matches that of single chips.

Table A-1 Progress in LSI Production Processes

Time frame	Design rule ( $\mu\text{m}$ )	DRAM max integration (bits)	SRAM access time (ns)	Gate array max integration (gates)	Micro-processor clock speed (MHz)
1993	0.5	16M	10	500K	75
1995	0.35	64M	7	1.6M	120
1997	0.25	256M	5	6M	200

For example, let us compare the mounting area for MCMs with that of printed circuit boards. If we take into consideration the effect of reducing the area for distribution lines, the mounting area can be reduced to 1/10-1/5 (Table A-2). However, there is also the effect that with the shortening of line length, signal propagation delay is reduced.

Table A-2 Reduction of Printed Circuit Board Area Using MCMs

	TAM10Z Series	TAM10C Series
MCM dimensions	48 x 48 mm <sup>2</sup>	40 x 40 mm <sup>2</sup>
Chips installed <sup>*1</sup>	TC160GU2 (120K gates) x 1, TC160G54 (22K gates) x 3	
Number of MCM signal layers	2	6
Reduction in area of printed circuit board, including distribution lines <sup>*2</sup>	1/6	1/5

<sup>\*1</sup>The areas of the TC160GU2 and the TC160G54 when packaged individually are 43 x 43 mm<sup>2</sup> (304 pin ceramic QFP) and 27 x 27 mm<sup>2</sup> (176 pin ceramic QFP), respectively.

<sup>\*2</sup>The mounting area of a printed circuit board, inclusive of the distribution lines, with all gate arrays packaged.

### Multiple Types with Different Materials and Characteristics

Though all are called MCMs there are several different types with different materials, structures, characteristics

and costs. In general, there are three classes MCM-L, MCM-C and MCM-D (Table A-3). They can also be divided according to range of applications, and the overall application range of MCMs is very broad.

Table A-3 Comparison of MCMs

	MCM-L	MCM-C	MCM-D (MCM-C/D)
Structure	MCMs that, after bare chips are mounted on printed circuit boards, are protected using potting.	MCMs formed with multi-layer distribution lines using simultaneously fired ceramics.	One type of MCM-D. MCMs in which thin film distribution lines are formed on a simultaneously fired ceramic board using organic resins.
Main fields of application	low-end consumer products (mid-low speed)	high-end consumer products (high-speed)	high-end products (very high speed)
Actual electronic equipment applications	VTRs, game equipment, home electronics	work stations, PCs, communications equipment, next generation game equipment	supercomputers, high-speed communications equipment, graphics equipment, etc.
Signal layer material	glass epoxy	alumina	alumina/aluminum nitride
dielectric constant	4-5	9-10	2.7-4
Distribution line width (μm)	100-200	50-125	10-75
Distribution line pitch (μm)	100-200	50-150	25-100

Considering distribution line pitch and width, bia [literal] diameter, board dielectric constant, thermal conductivity, etc., we move toward the high-speed and high-density application range as we go from MCM-L to MCM-C to MCM-D, and the costs and TAT increase.

MCM-Ls use glass and epoxy as the board materials, and they can basically be called high-speed printed circuit boards. The board thermal conductivity of MCM-Ls is 50 times worse than that of alumina, which is used for the boards in MCM-Cs, and they are not appropriate for high-speed applications that generate a great deal of heat. In addition, with the design rules for the MCM-Ls up to this point, the mounting efficiency is low and the range of applications is limited.

MCM-Cs are appropriate for covering the range from an area near consumer products to that just before the very high speeds of high-end products at present. In addition in the range above this, the electrical characteristics of MCM-Cs make them difficult to use, and MCM-D technology is necessary. Since MCM-Ds have low dielectric constants, and are miniaturized using thin film processing, they are appropriate for very high-speed

fields. Among these, MCM-D/Cs have the characteristics of MCM-Ds, but can be produced with comparatively low cost; they will probably become the mainstream in high performance fields.

### NEC Develops Tantalum Oxide Capacitor Dielectric Film

94FE0250A Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 16 Dec 93 p 5

[Text]

### Tungsten Used Between Layers; Capacity is 2.6 Times Greater For 1 Gigabit DRAM

NEC (President, Mr. Tadahiro Sekimoto) has developed a capacitor cell that uses an ultra-thin tantalum oxide film in the capacitor dielectric film used for 1 gigabit DRAM. Practical application of tantalum oxide is now certain; although its insulating capability is several times that of silicon oxide film, it was considered difficult to employ in a 1 gigabit DRAM. Hemispherical grain (HSG) polycrystalline silicon is utilized in the lower

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electrode and, by inserting tungsten between the layers, tantalum oxide is made into a 1.6 nanometer thin film through a silicon oxide film conversion. Moreover, the capacity increases to 2.6 times the present capacity while it limits the electrode height that allows an exposure margin. NEC considers the tantalum oxide film to be a strong candidate in promoting development of 1 gigabit DRAM.

The tantalum oxide capacitor cell's lower electrode is composed of the same poly-silicon currently used, and is in a HSG structure in order to gain area. In addition, in order to prevent the natural oxide film that adheres and thickens right after tantalum oxide is made, tungsten is formed on the topmost surface of the lower electrode, and tantalum oxide is then deposited by means of the chemical vapor deposition (CVD) method. A titanium nitride film is used for the upper electrode.

Because the tantalum oxide's leakage current increases when tungsten is inserted in the space, low temperature oxygen plasma processing is performed at 300°C, which improves the quality of the tantalum oxide film. This has the effect of removing tungsten oxides, which evaporate easily at low temperatures, and is said to be better for making capacitor dielectric films thinner.

The film can be as thin as 1.6 nanometers by means of a silicon oxide film conversion, and a capacitor cell can be made that ensures a capacity sufficient for 1 gigabit. Up until now, the thickness of the converted film was limited to approximately 3 nanometers in the structure that immediately produces tantalum oxide on the top of the lower electrode, due to natural oxidation and a low specific inductive capacity. However, area is gained through HSG, and because the film can be made even thinner with tungsten, the capacity is increased to 2.6 times the capacity using present methods, and the thickness of the converted film is cut in half. The height of the lower electrode that assures the capacity needed in a 1 gigabit DRAM is 0.6 microns, which allows a sufficient exposure margin for mass production.

High dielectric substances are needed to ensure capacity for 1 gigabit, such as barium, strontium and titanium oxides (BST) and lead, zircon and titanium oxides (PZT). However, in addition to issues such as film quality and the inability to use the poly-silicon currently used on the lower electrode, the specific inductive capacity of the tantalum oxide film is five to six times greater than that of a silicon oxide film, but is far smaller than that of high dielectric substances, making it difficult to ensure the capacity needed for a 1 gigabit DRAM. In contrast, tantalum oxide is a material that easily forms films under existing conditions without worry of contamination, and has the ability to take over technologies using poly-silicon in the lower electrode. NEC is treating tantalum oxide as a strong candidate for its 256 megabit to 1 gigabit DRAM.

#### **Mitsubishi Achieves Up To 100 Times Increased Transistor Life**

94FE0250C Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 10 Dec 93 p 5

[Text]

#### **Nitrogen Ions In the Gate Electrode**

Mitsubishi Electric Corp. has succeeded in introducing a new structure for transistors used in next-generation high integrated circuits of over 265 megabits (1 megabit = 1 million bits); this increases transistor life by 10 to 100 times. Nitrogen ions are implanted in the gate electrode that regulates the flow of electrons, which are intended to prevent the oxide film portion that constitutes the element from deteriorating. The news was announced at the International Electronic Device Conference held in the United States.

Large-scale integrated circuit (LSI) transistors have three electrodes which control the entrance, exit, and flow of electrons. The smaller the transistor, the shorter the distance between the entrance and exit electrodes, and the higher the energy held by the electrons. These electrons have excess energy and jump into the oxide film, which causes deterioration of the element's properties.

In order to solve this problem, Mitsubishi Electric employed a new method where nitrogen ions are implanted into the gate electrode, which is made of polycrystalline silicon. If nitrogen ions are implanted in poly-silicon the nitrogen diffuses, and prevents deterioration of the oxide film. This is because nitrogen blocks the high energy electrons' attempts to enter the oxide film.

The size of next-generation LSI transistors that exceed 256 megabits is 0.25 microns (1 micron = 1/1000 mm). In order to maintain reliability at this size, every semiconductor company is responding by lowering the voltage used as much as possible, and improving oxide films.

If transistor life is increased, LSI lifespan will increase as well. Improving production methods will also be resolved just by adding the ion implantation process to existing processes.

#### **Hitachi Achieves Single Electron Memory Cell Operation at Room Temperature**

94FE0250B Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 8 Dec 93 p 9

[Text]

#### **Paves Way For 16 Gigabit Memory; Low Power Consumption Possible**

On 7 December, Hitachi, Ltd. (President, Mr. Tsutomu Kanai) announced it had achieved the world's first single electron memory cell operation at room temperature. One electron can store one bit of information, and is

linked to ultimate high integration and low power consumption. Hitachi had already operated a single electron memory cell at low temperatures, but this time, the company was able to create a microstructure that could confine a single electron at room temperature with a polycrystalline grain diameter of 10 nanometers, using existing silicon technology. It has been confirmed that a single electron stored in a crystal grain can be preserved for more than a month; this is attracting attention as a means for paving the way for a 16 gigabit non-volatile memory that can store 30 years of newspapers.

This technology came about in cooperation with Hitachi Europe's Cambridge Research Institute. The experimentally produced elements are common MOS (metal oxide semiconductor) transistors intersecting at right angles, with an oxide film inserted between the channel and gate electrodes between the source drains. Each electrode consists of polycrystalline grains with a 10 nanometer diameter, and the current flows while selecting the least energetic crystal grains.

When a high gate voltage is given to the element, a single electron from the current's path tunnels into nearby low energy crystal grains that are isolated, and is captured. These isolated crystal grains become the charge storage for the non-volatile memory and, because the next electron cannot enter when a single electron is captured due to the repulsive force, in principle, operation takes place with a single electron. The capture of electrons one by one by the crystal grains confirms the fact that the value of the current sporadically changes when the gate voltage is raised, and the amount of change corresponds to the value of a single electron.

#### **Toshiba Develops Technology to Lower Manufacturing Cost of 256MB DRAM**

94FE0250D Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 15 Dec 93 p 5

[Text]

#### **Four Cells Wired Together; Area 44% Smaller; Demand for Lower Cost Product Forecast**

Toshiba Corp. has developed technology that can lower the production costs for next-generation 256 megabit DRAM (an always accessible read-write memory needed to operate storage protection). A new connection method was employed, which wires together the four basic elements (cells) that makes up DRAM, making trench-type cell wiring possible with pre-first-generation microprocessing. The retrieval speed for stored information is slower than at present, but can be done at a lower cost. Toshiba sees a demand for DRAM in which high speed does not matter, and will begin trial production of and exploring markets for the memory.

The trench cell is also called a ditch cell, and is Toshiba's own cell that the company has been using in its DRAM.

A slit structure is made deep in a silicon substrate, making it possible to store the amount of charge needed for information storage.

Then cells are formed by creating an opening 5 microns deep (1 micron = 1/1000 mm) with a diameter of 0.5 microns. A new connection method, the "NAND structure", is used, which links the four cells in a line; this is connected to the bit line which is the information path.

As a result, the number of connections is reduced by 25% compared to DRAM in which the cells are wired one at a time, and the area can also be reduced by that amount. The cells are 44% smaller than DRAM cells currently used, and 256 megabit DRAM can be made with microprocessing technology at the 4 micron level that is used for 64 megabit DRAM production.

Toshiba has a positive record for trench cell production, and expects to lower costs because of the simple structure, but until now, the adjacent paths that are linked at the openings were obstructed and could not be wired together very well. This time, this problem can be dealt with by the new connection method, which staggers half the openings.

Toshiba has been experimentally producing NAND type DRAM using stack-type cells, but the stack cell entails creating a complex three-dimensional structure cell on the substrate, which complicates the production process.

DRAM with the new connection method is 10-20 times slower, but can be produced at a low cost. It cannot be used as a substitute for the DRAM used in a computer's main memory, but Toshiba believes that there will be a new demand for low-cost DRAM in which speed is not important. The 256 megabit DRAM that Toshiba will be putting to practical use in its early stage of development is the same DRAM that is being developed jointly with IBM in the U.S. using current methods.

#### **Mitsubishi Develops New 256MB DRAM Technology**

94FE0250E Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 9 Dec 93 p 4

[Text]

#### **High Dielectric in Memory Element; Costs Less Than Silicon**

Mitsubishi Electric Corp. has developed a new memory element (cell) for a next-generation memory 256 megabit DRAM (an always accessible read-write memory needed for operating storage protection). Its distinguishing characteristic is that it uses a dielectric that easily stores a charge of barium, strontium and titanium oxides (BST) in the material. Because the structure of the memory element can be greatly simplified, compared to the dielectric films currently used, the number of manufacturing processes can be reduced, which lowers costs. By using this method, trial manufacture of 256 megabit

DRAM can go ahead, and practical application at the early stage of development is intended.

NEC, Fujitsu, and other companies began trial production of 256 megabit DRAM this spring, but the memory element uses a complicated three-dimensional structure. Mitsubishi intends to fight back with its DRAM, which applies the new technology for mass production.

The DRAM memory element becomes more minute as the degree of integration increases, and making the films ultra-thin is necessary. But if the element is too small, the amount of electric charge needed for storing information cannot be stably stored. Because there is a limit to how thin a film can be, semiconductor companies maintain the amount of charge by creating a three-dimensional structure with a cylindrical or wing-shaped memory element. However, this kind of processing is difficult, and the number of processes increases.

Mitsubishi has responded by changing the material itself. The BST now being used can store a charge more than 10 times greater than a silicon dielectric film. But if the film is made thinner this ability drops, and there are difficulties with leakage of current. As the company looks for thin film production conditions in which the BST crystal configuration is at an optimal state, it is microprocessing by ion etching, which uses a magnetic field.

The memory elements that are being experimentally produced have a flat structure, with the BST film inserted between platinum electrodes; the area is 0.72 square microns (1 micron = 1/1000 mm). The amount of charge need can be maintained, and the current leakage is minimal. The number of processes have been cut in half compared to manufacturing a three-dimensional memory element. Processing the memory element comprises 10% of DRAM, so costs are reduced. BST films are 30 nanometers thick (1 nanometer = one-billionth of a meter), and seem to be applicable in even higher integrated DRAM if made even thinner.

The results of the research on the new technology was announced at the International Electronic Device Conference held in the United States, but the performance of the 256 megabit DRAM will not be made public until a conference next spring.

#### **Mask for Mass Production Developed; Microstructure Easily Processed**

Mitsubishi Electric has developed a custom mask that imprints a high-precision 256 megabit DRAM circuit

pattern onto a substrate. Because the mask can be used in combination with a krypton fluoride excimer laser, the microstructure needed for the 256 megabit level can be processed with ease. This technology opens the way for mass production of next-next-generation semiconductors.

A semiconductor is made by copying a circuit blueprint onto a substrate just as a picture is imprinted with a negative. 256 megabit semiconductors require 0.25 micron microprocessing technology. Because this is nearly identical to the wavelength of the high-tech excimer laser, even slight deviations are not permitted, and processing is approaching the limits.

The mask developed was created with a quartz substrate, and is used by covering the portions other than the circuit with a molybdenum silicide oxide film. Besides transmitting only 10% of the light from the excimer laser, the molybdenum silicide oxide film reverses the light's phase. So the light is transmitted to the quartz as is. As a result, the properties of the light on the circuit portion and on the rest of the substrate are completely different, which causes the pattern boundary lines imprinted on the substrate to be distinct. A special characteristic is that as light passes through the non-circuit portion, its intensity is weakened so that imprinting does not occur. The circuit pattern is made sharply conspicuous and is copied onto the substrate; processing precision is vastly improved, with the circuit measuring less than 0.05 microns.

By using the experimental mask and the excimer laser, the internal diameter is a mere 0.2 microns, the smallest opening ever achieved. This has been shown to be effective for 256 megabit semiconductor production. In addition, the new mask simplifies the structure, and with fewer defects, production is also simplified.

Since microprocessing capabilities have enlarged in scope, improvements in the assembly procedure are forecast, and mass production can be tackled. Furthermore, if an optical system is devised, processing technologies using existing facilities and the excimer laser light source could even be applied to 1 gigabit (1 gigabit = 1 million bits) semiconductors. At the present time, 64 megabit level semiconductors are on the market at the sample stage, and it appears that 256 megabit level samples will be out three years from now.

**Patent Office Announces Policy to Shorten Examination Period to 19 Months**

94FE0811A Tokyo NIHON KEIZAI SHIMBUN  
in Japanese 25 Jul 94 p 3

[Text] With the agreement reached in the Japan-U.S. framework on trade on intellectual property rights, the Patent Office will significantly shorten the patent examination period. Along with changing the time period during which a third party can contest a patent—changing from during the examination period to after the patent goes into effect—the Patent Office will revise its application of the examination system so that more patent applications will be given priority for examination. The goal is to implement both policy changes in FY96. If the changes are realized, the average examination period can be shortened from the current 28 months to 19 months, which is the length of the examination period in the U.S. The Patent Office is also working to shorten the time period prior to examination, i.e., from the time the patent application is submitted to the time when the examination begins. The average period from the time the application is submitted to the time the patent is recognized has been five to six years. The Patent Office will work to shorten that period to three to four years.

By examining and protecting inventions as quickly as possible, the Patent Office hopes to stimulate enthusiasm for R&D in firms that intend to convert new technologies into products. The idea is that it will lead to the cultivation of new enterprises and venture firms.

The system for contesting a patent is one in which a third party's objection that "this invention should not be patented" is accepted during a period of three months from the date on which the patent application was announced, and the objection is considered in the examination. Because that system is a factor that prolongs the examination period, the Patent Office will change to a system in which an objection will be accepted after arrangements are made for protection in the form of a patent, and the patent will be re-examined in cases where the objection is recognized. The Patent Office will submit a proposal for revision of the Patent Law at the extraordinary session of the Diet in the autumn.

The patent applications given priority in the Patent Office's examinations are now limited to applications from firms, etc., that plan to commercialize the invention within six months from the date on which a priority examination is requested. The Patent Office is looking into broadening that to include "applications for which the planned time until commercialization is three years." That is because of the increasingly stronger tendency toward more sophisticated products and a longer period from the time a technology is established until it is converted into a product.

In addition, the Patent Office will work toward shortening the period from the time a firm, etc., applies for a

patent to the time that the examination begins. The Patent Office's policy is to shorten the period from the time an applicant requests an examination to the time when the office actually begins the examination from the current two years to less than one year by 1998, and to shorten the maximum period during which an examination can be requested from the current seven years to three years by 1999. The Patent Office is also discussing making it the applicant's responsibility to conduct an advance study to investigate whether or not the same invention was contrived in the past, and fostering examiners who can investigate several technical fields at the same time.

Until now the issue of shortening the examination period has been brought up mainly between Japan and the U.S., with the U.S. pressing for shorter examination periods in Japan. Even after Japan agreed to shorten the average examination period to two years by the end of 1995 at the Japan-U.S. Structural Impediments Initiative in 1990, the U.S. repeated its demands for shortening the examination period.

**Government To Review Policy on Patents, Intellectual Rights**

43070104A Tokyo THE NIKKEI WEEKLY in English  
13 Jun 94 p 13

[Text] In order to attract foreign companies to its "new energy" research projects, Japan has decided to review government policy regarding patents and intellectual property rights.

National research projects in the new energy field are subcontracted out to private corporations and universities by the New Energy and Industrial Technology Development Organization. The research projects concern such topics as solar energy, geothermal energy and more efficient use of coal resources.

Under the existing policy, all patents and intellectual property rights resulting from such research projects belong to the Japanese government and cannot be freely used by the corporations and universities involved in their creation. Japan has proposed a number of international joint research programs in the energy field, but foreign companies tend to shy away because of these restrictions.

Japan now plans to review this policy, government sources say. In the future, intellectual property rights will be shared with the participating companies. This will enable firms to transform the results of joint research into business opportunities. In addition, the government is thinking of lowering the royalties charged to foreign co-developers wishing to use the technology.

The Japanese government already recognizes joint ownership of intellectual property rights deriving from national research projects in the new materials and biotechnology fields.

### Japanese S&T Developments Reported

[Text] Hitachi has developed a red semiconductor laser featuring a low reflection noise. The HL6727MG operates at a wavelength of 690nm with an output power of 5mW and has a reflection noise factor of over 70dB. The new laser helps increase the recording density compared to the 780nm lasers currently used in optical disk systems, and improve sound and video quality of compact and laser disk systems. A wider operating temperature range of up to 60° C makes it a potential fit for industrial barcode readers. The 5.6mm-diameter laser samples become available in July for 3,600 yen (\$34.62) apiece, with production slated for October at 2,000 units a month. (Tokyo NIKKAN KOGYO SHIMBUN 20 Jun 94 p 8)

NEC will introduce a 64bit RISC (reduced instruction set computer) microcontroller based on the MIPS Technologies architecture as early as early 1995. Code-named T5, the RISC chip will provide floating point and integer operation performances of 300SPECfp92 and 200SPECint92, respectively, when running at 200-250MHz. NEC intends to device a multi-faceted MPU strategy in which it will target high-end chips like the T5 at image processing workstations and low-end chips at game machines. (Tokyo NIKKEI SANGYO SHIMBUN 20 Jun 94 p 8)

Professor Ikeda's research group at the Research Laboratory of Resources Utilization at the Tokyo Institute of Technology has developed a liquid crystal photonics material which features a response speed of less than 200 microseconds. It has been said that 50ms is the limit of optical phase transfer speed with conventional nematic liquid crystal photonics materials. The group has changed the molecular shape of all liquid crystal molecules by building light response elements into them to minimize losses in trans-cis isomerization speed, thus boosting response speed. (Tokyo KAGAKU KOGYO NIPPO 20 Jun 94 p 10)

Kansai Electric Power (KEP) has disclosed a ten-year plan beginning this year to invest approximately 160 billion yen (\$1.54 bil) to install optical fiber cables to four million households, approximately 40% of all the households it currently supplies electricity to. The company's intention is to build its own communications network in preparation for the coming multimedia age. The effort represents the biggest network construction project aimed at average households ever undertaken by an electric power firm in Japan. KEP currently has a 5,300km optical fiber cable network which connects its headquarters with branch and sales offices. (Tokyo YOMIURI SHIMBUN 18 Jun 94 p 9; Tokyo NIHON KEIZAI SHIMBUN 19 Jun 94 p 7; Tokyo NIHON KOGYO SHIMBUN 20 Jun 94 p 13)

MITI has decided that one key area that its policy for fiscal 1995 will focus on will be promoting the development of new technology in order to create new markets.

The ministry plans to implement concrete measures in four key areas: (1) promoting greater flow and exchange of researchers, (2) providing capital for facilities for high-level research, (3) providing support to help new technologies develop to the business stage, and (4) establishing a system of intellectual property rights. (Tokyo NIKKAN KOGYO SHIMBUN 20 Jun 94 p 1)

Toshiba plans to develop in 1995 a UNIX server that can run continuously for 24 hours. To be developed in response to the increase in demand for fault-tolerant servers as client-server systems become more widespread, the server will use a symmetric multi-processor construction and software and hardware methods to provide fault-tolerant operation. As price has become an issue for fault-tolerant LAN servers, the company will keep the price of the new product low. By using two CPUs, Toshiba intends to give it high availability. Disk drives and other I/O devices will be shared, allowing quicker responses to malfunctions. (Tokyo DEMA SHIMBUN 20 Jun 94 p 4)

Toshiba has developed a prototype optical fiber encoder which uses light to detect the rotation speed of a small motor in the order of millimeter. Made of an aluminum alloy and using about 1/10 the number of components conventional encoders require, the cylindrical prototype, 2.6mm in diameter and 3.5mm in circumference, has a rotating axis in the middle which is connected to a motor to be measured and has a small disk made of nickel attached to the tip of the axis. The disk has 75 slits at equal intervals, and 850nm infrared light passing through an optical fiber is emitted on the disk. Optical signals on the reflected light coming back through the fiber is converted into electric signals and is processed using a computer to accurately measure the number of rotations in a unit time. In an experiment, the company succeeded in detecting a 1.2-degree change in an angle when the prototype was rotating at 600rpm. (Tokyo NIKKEI SANGYO SHIMBUN 21 Jun 94 p 4)

NEC has developed a T-shaped prototype field effect transistor for use in milliwave and microwave radio communications. The length of the FET's gate electrode has been reduced to 70nm, less than half the 150nm which was considered a limit, and the prototype's amplification factor in the 12GHz band, which is used in satellite communications, has been nearly doubled to 32-40 times, twice as more efficient as FETs commercially available. Electron ray resist is first coated on a semiconductor substrate, and then by exposing electron rays a 100nm-wide trench is created. After resist sensitive to ultraviolet rays is coated over the trench, it is exposed to i-line rays. When used in satellite broadcasting receiver antennas, the new FET can help reduce the antenna diameter by 7.5cm to 30cm while guaranteeing the same level of reception quality. (Tokyo NIKKEI SANGYO SHIMBUN 21 Jun 94 p 4)

A committee set up by MPT to address problems relating to ATM (asynchronous mode transmission) networking

technology released its report on June 20. While ATM exchanges are already partially in use for connecting LANs, the report suggests that more technological development and greater standardization be required for ATM data transfer via cable TV. The committee recommends that tax relief and financial support measures for installation of ATM switches be implemented in the fiscal 1995 budget, and also calls for more active promotion of tests and standardization. (Tokyo NIKKAN KOGYO SHIMBUN 21 Jun 94 p 11)

KDD plans to invest a total of 1 trillion yen (\$9.71 bil) in international information highway development by 2010. In cooperation with AT&T and other foreign common carriers, KDD will lay large-capacity submarine optical fiber cables connecting the U.S., Europe, Asia, and the Pacific region to provide various multimedia services such as international remote medical diagnosis and teleshopping services. (Tokyo DEMPA SHIMBUN 21 Jun 94 p 2)

Hitachi has developed and will on June 23 begin taking orders for a parallel supercomputer with 23gigaFLOPS (floating point operations per second) capability. The SR2001 uses a maximum of 128 RISC (reduced instruction set computer) processors based on Hewlett-Packard's PA-RISC architecture. Hitachi has incorporated its proprietary 3-D crossbar network to improve efficiency in communications among processors. The supercomputer runs HI-UX/MPP, a UNIX operating system, and the company has made available programming languages such as FORTRAN and C Compiler as well as numerical computation library software. Prices start at 70 million yen (\$686,275). Shipment is slated for March 1995. Hitachi is aiming to ship 100 units in five years, and plans to release a massively parallel supercomputer with a processing capability of 1teraFLOPS in fiscal 1996. (Tokyo DEMPA SHIMBUN 22 Jun 94 p 5, Tokyo NIKKAN KOGYO SHIMBUN 22 Jun 94 p 10, Tokyo NIHON KOGYO SHIMBUN 22 Jun 94 p 10, Tokyo NIKKEI SANGYO SHIMBUN 22 Jun 94 p 6)

Nikon Technologies has developed a measuring system with a resolution of 0.4nm. Based on the technology developed by its parent company Nikon and the National Research Laboratory of Metrology of the Institute of Industrial Science & Technology the system is placed on a 10cm-diameter, 2cm-thick disk, has a measuring range of up to 10 microns, and can mount a sample as large as 10mm square. The system, which integrates optical elements such as a prism, uses a laser interferometer which emits a 633nm helium neon gas laser to measure and observe VLSIs, micro-machines, and biological samples. (Tokyo NIKKEI SANGYO SHIMBUN 22 Jun 94 p 3)

Fujitsu has developed a 10.4-inch thin-film transistor color LCD which saves power by 30% to 4.3W compared to conventional LCDs which usually consume over 6W. Nearly 70% of the power is said to be consumed by a backlight unit. Fujitsu has replaced two backlights with

one and increased the transmissivity of a polarization plate and color filter to 7%, up from 3% with conventional units. The company claims that a notebook PC equipped with the new LCD runs about five hours on a single recharge, a 25% increase. Fujitsu plans to begin production as early as this month and mount the new unit on a new PC to be released this fall. The company will also expand sales to other firms by focusing its TFT color LCD product line on the new unit and an LCD with a 120-degree angle of field. (Tokyo NIKKEI SANGYO SHIMBUN 22 Jun 94 p 1)

Deregulation of connections between NTT's local public phone lines and corporate leased lines should encompass international as well as domestic communications, according to a final recommendation made June 22 by a data communications subcommittee of the government's Council on Administrative Reform. The subcommittee also recommended that the frequency of inspections of radio stations belonging to domestic telephone carriers be reduced from once yearly to once every five years, and that restrictions on the output of regional community broadcast stations be relaxed. In addition to improving convenience for domestic communications users, the recommendations encompass issues which will have significant impact on overseas communications service providers such as VAN carriers. (Tokyo NIHON KEIZAI SHIMBUN evening 21 Jun 94 p 1)

NEC has developed a low-voltage 64Mbit flash memory cell with a program/erase endurance of over 100,000 cycles. Designed using a 0.4-micron CMOS technology, the new cell requires an internal voltage of less than 12V for the program and erase operations, allowing it to operate from a 3.3V single supply. Conventional flash memory cells require an internal voltage of 18V and therefore a special circuit. The cell size is 1.5 sq. microns. The gate insulation oxide is 20nm thick to increase the capacitive coupling ratio from 0.5 to 0.8. The floating gate tunneling oxide is as thin as 7.5 microns. (Tokyo NIHON KOGYO SHIMBUN 22 Jun 94 p 7)

MPT has firmed up its policy concerning the method it will adopt for allowing carriers into the promising personal handy phone system (PHS) market. The ministry plans to adopt a system of eight to nine regional blocks in order to prevent the overconcentration in metropolitan areas it fears would arise if carriers were allowed to enter a single, nationwide market. The policy means it is likely that aspiring PHS carriers such as DDI will enter the market by establishing subsidiaries in each block. (Tokyo DEMPA SHIMBUN 22 Jun 94 p 2)

Matsushita Electric, in cooperation with Matsushita Electronics, has developed an audio equipment D/A converter IC featuring 1/10 the transmission noise of earlier models. The new converter uses a newly-developed special circuit instead of a conventional PWM (pulse width modulation) circuit to minimize the jitter, a cause of noise, and increase the dynamic range from 100dB to 120dB. Matsushita Electric, which will use the

new converter for a digital audio system it will launch this fall, is considering marketing it to other firms targeting digital audio equipment and satellite broadcasting equipment applications. (Tokyo NIKKAN KOGYO SHIMBUN 23 Jun 94 p 9)

Totoku Electric, in cooperation with engineering company Emit Seiko, has developed an optical fiber edge polishing system which allows for precise and speedy connection of two optical fiber cables. The TEP801 first processes the optical fiber edge into a circular cone and corresponds the top of the cone to the center of the fiber. It features a difference between the center of a polished concave and the fiber core of less than 50 microns. The system can process an edge in four minutes. Sample shipment begins on July 1. (Tokyo NIHON KOGYO SHIMBUN 23 Jun 94 p 9)

The Ministry of Construction has released a report compiled by a committee set up to preside over the ministry's information and communications policy, which will be used to set policy by the end of fiscal 1994 on plans for a nationwide information and communications network. The ministry will support these activities by constructing roads, carrying out river improvements and laying sewage pipes, etc. with easily accessible conduits and boxes so they can carry optical fiber cables. The ministry also has plans for its own information system, which could be used to create a new system for bidding and awarding contracts on construction projects. (Tokyo NIKKAN KOGYO SHIMBUN 23 Jun 94 p 21)

Ulvac has developed a hydrogen annealing furnace for the manufacture of next-generation memory devices such as flash memory and 64Mbit DRAM chips. Hydrogen annealing is drawing attention as a technique to improve wafer quality. The V8-100L-H2 is designed to heat wafers in a hydrogen gas atmosphere to over 1,200 deg C and reduce the oxygen atoms near the wafer surface to lower the oxygen concentration of 10E18 by two digits. Ulvac will strive to take orders for 10 systems in the fiscal year ending June 1995 to catch up with Kokusai Electric and Shinko Electric which lead the market (Tokyo KAGAKU KOGYO NIPPO 23 Jun 94 p 9)

Toshiba has developed a high-speed NAND flash memory cell program circuit. Toshiba's NAND flash memory cell uses an internal charge pump to secure a program voltage of 20V while operating from a single 5V power supply. The new circuit is designed to vary the amount of charges to be supplied depending on the voltage level: it supplies a large amount of charges in parallel when the voltage level is near 5V and supplies charges serially once the voltage level is boosted to a certain level. This method helps speed up voltage boosting and therefore reduce programming time. The new circuit can be applied to the flash memory as well as other LSIs requiring an internal charge pump. (Tokyo NIKKAN KOGYO SHIMBUN 23 Jun 94 p 7)

MPT will convene as early as July a panel to study the convergence of communications and broadcasting in the 21st century. The group will consider issues such as the ways different information providers will use optical fiber networks amid the transformation of the media industries widely expected to take place as multimedia technologies become commonplace. The new committee will bring together service providers from many sectors, including newspaper publishing, broadcasting, cable television, telecommunications, and conventional publishing. (Tokyo DEMPA SHIMBUN 23 Jun 94 p 1)

Fujitsu has developed a prototype semiconductor laser with a built-in tapered waveguide, which has radiation angles of 8 degrees horizontally and 11.8 degrees vertically, less than 1/5 those of conventional devices. The prototype integrates a laser emitting multi-quantum well active layer and a tapered waveguide which narrows a radiation angle, both of which are formed simultaneously through metal organic chemical vapor deposition. Using the deposition technique, the company has reduced the thickness of a 200-micron-long spot-size converter until one end becomes 1/5 the thickness of the other end, a structure which helps weaken the optical enclosure capability of the waveguide and enables light to widespread while passing through the waveguide, making the light emitting end less susceptible to diffraction. When a laser beam emitted from the prototype is concentrated on a 10-micron-diameter single-mode optical fiber through a lens, coupling efficiency has improved by 5dB, nearly a quadruple increase. (Tokyo NIKKAN KOGYO SHIMBUN 24 Jun 94 p 7)

MPT will implement new standardization policies for the communications and broadcasting sectors in order to prepare more effectively for the widespread use of multimedia technologies. The ministry decided that efficient and specific standardization measures are needed in light of the rapidly increasing pace of technological innovation and industry interest in multimedia. Toward this end it will ask the Telecommunications Technology Council to deliberate standardization issues beginning with its next-scheduled meeting June 27. The effort is expected to focus initially on interconnection standards to accommodate the convergence of communications and broadcasting and clarification of the relationship between de facto and international standards. (Tokyo NIKKAN KOGYO SHIMBUN 24 Jun 94 p 11)

Hitachi has developed a technique for shooting a picture of the distribution of an atom in a sample at a resolution of 1nm; conventional techniques achieve a resolution of 2.5nm. It takes about 20 seconds to measure the atomic distribution of a 0.1-sq.-micron sample with the new technique, while it takes 4.6 hours with conventional systems. The technique, which uses a transmission electron microscope, can alter an electron ray's accelerated voltage by 0.5V, and therefore the energy level of electron emission can be set precisely. The technique has also reduced shutter speed to 0.05 second; conventional approaches have a hard time clearing the shutter speed

of 0.5 micron. The new technique is expected to be used in R&D for semiconductors and magnetic materials. (Tokyo NIKKEI SANGYO SHIMBUN 24 Jun 94 p 5) Mitsubishi Electric has developed a simple-structured low-voltage positive transistor using a 0.25-micron CMOS process. The new transistor uses a positive polysilicon gate electrode to which nitrogen is implanted to minimize the fluctuations of threshold voltage and to prevent the insulator from deteriorating due to hot carriers. The transistor is capable of operating on 2.5V. The company will continue working on the transistor in an attempt to develop 256Mbit DRAM and low-voltage LSI chips. (Tokyo KAGAKU KOGYO NIPPO 24 Jun 94 p 9)

NTT will shortly begin a three-year period of fiber-optic communications network experiments in the medical sector in cooperation with the National Cancer Center and Keio University. MRI and CT images will be transmitted between NTT research labs and hospitals using super-high resolution imaging equipment in tests of remote diagnostic applications and integrated management of various types of medical data. It will be the first set of medical sector experiments in Japan to use fiber-optic networks to transmit very high resolution images. (Tokyo NIHON KEIZAI SHIMBUN 24 Jun 94 p 13)

MPT will establish an official third-party organization as early as within fiscal 1995 to smooth interconnection negotiations between NTT, the new common carriers (NCC), VAN providers, and cable television (CATV) companies. It will also draft guidelines to help drive the interconnection effort. The purpose of the move is to promote the diversification of Japan's communications services, an area in which the nation lags Europe and the U.S. NCCs such as DDI and regional carriers such as Tokyo Telecommunication Network cannot provide many new services without connections to NTT's networks. (Tokyo DEMPA SHIMBUN 24 Jun 94 p 3, Tokyo NIKKAN KOGYO SHIMBUN 24 Jun 94 p 11, Tokyo NIHON KOGYO SHIMBUN 24 Jun 94 p 11)

MPT has set the year 2010 as its target date for having a nationwide fiber-optic network in place. The decision, made June 24, was based on a May 31 report from the Telecommunications Council concerning Japan's data communications infrastructure program. MPT also determined a specific schedule of milestones for achieving the goal, including having public-use applications at the practical stage by 2000 and having the network cover 60% of Japan's population by 2005. (Tokyo DEMPA SHIMBUN 25 Jun 94 p 2, Tokyo NIKKAN KOGYO SHIMBUN 25 Jun 94 p 5)

Tokyo CATV, the cable television arm of the Tokyo Group, will as early as September begin experiments whereby a new common carrier's personal handy phone system (PHS) network is interconnected with TOKYU's CATV network. It will be Japan's first experiment connecting PHS to CATV. Regional carrier Tokyo Telecommunication Network will act as Tokyo CATV's partner

in the experiments, which will take place in Tokyo. CATV stations see PHS as a promising non-broadcast application which they hope will serve to boost CATV usage. (Tokyo NIKKAN KOGYO SHIMBUN 25 Jun 94 p 1)

DDI will gradually establish personal handy phone system (PHS) companies in each of 10 regions around the country. In accordance with guidelines on the PHS business set up by MPT, the companies will apply for operating licenses starting in the fall. The move will give DDI a nationwide group of communications companies that aim to set up a secondary, local network. Just as in the case of its group of eight cellular phone companies, DDI will hold the majority of shares in the new companies, investment in which will be solicited from leading companies in the regions. The companies will be responsible for developing capital investment plans and sales strategies based on market trends in their respective regions. (Tokyo NIHON KEIZAI SHIMBUN 26 Jun 94 p 7)

Nippon Sanso and Professor Takushoku's research group at Keio University have jointly developed a system for reducing the amount of dissolved oxygen in ultra-pure water to 0.2ppb (particles per billion). Conventional techniques cannot lower the level below 1ppb. The nitrogen gas bubbling technique uses polyvinylidene fluoride (PVDF), an engineering plastic with a low oxygen transmissivity, in order to prevent oxygen in the atmosphere from passing a vinyl chloride material and mixing into ultra-pure water. Designed for use in 256Mbit DRAM production, the prototype system can process 1 ton of water per hour, but the company intends to expand the system's processing capacity to 20 tons per hour. (Tokyo DEMPA SHIMBUN 28 Jun 94 p 2, Tokyo NIKKAN KOGYO SHIMBUN 28 Jun 94 p 22, Tokyo NIHON KOGYO SHIMBUN 28 Jun 94 p 16, Tokyo NIKKEI SANGYO SHIMBUN 28 Jun 94 p 13, Tokyo KAGAKU KOGYO NIPPO 28 Jun 94 p 1)

Toshiba has developed a 1Gbit DRAM NAND memory cell array featuring low noise. The new cell array adopts the folded bit line structure used for standard NOR-type DRAM cells and integrates control gates for each bit line to cancel noise. The new NAND cell size is 62.5% the size of a NOR cell. The company, which has fabricated a 3x2.5mm 64Kbit test chip using a 0.7-micron technology and confirmed normal operation, believes that the new cell architecture will pave the way for implementing a 1Gbit DRAM using 0.2-micron rules. (Tokyo NIKKAN KOGYO SHIMBUN 28 Jun 94 p 6)

NTT has developed a sound compression technique which is conducive to transmitting sound data. The TWINVQ (transform domain waited interleaved vector quantization) method enables 768Kbit/s CD-quality sounds to be compressed to less than 64Kbit/s, less than 1/2 the speed of the international MPEG-Audio voice compression standard. NTT claims that the technique will permit text data and still images as well as sounds to

be transmitted simultaneously via the INS Net 64 ISDN (integrated services digital network). The company plans to use the technique for such applications as "karaoke" sound transmission. (Tokyo DEMPA SHIMBUN 28 Jun 94 p 2, Tokyo NIKKAN KOGYO SHIMBUN 28 Jun 94 p 11, Tokyo NIHON KOGYO SHIMBUN 28 Jun 94 p 7, Tokyo NIKKEI SANGYO SHIMBUN 28 Jun 94 p 5)

Nikon will introduce a light wave interference coordinate measuring system on July 1. A successor to the 3i which went on sale in 1988, the 5i uses laser light interference to automatically measure LSI circuit pattern position coordinates, line widths, and pitch dimensions. The new model has a 40% higher throughput compared to the predecessor and a high reproducibility of 10nm, and can be used for the manufacture of 256Mbit DRAMs. The system price is 180 million yen (\$1.8 mil). Nikon projects first-year sales of 5 units. (Tokyo NIKKAN KOGYO SHIMBUN 28 Jun 94 p 9, Tokyo NIKKEI SANGYO SHIMBUN 28 Jun 94 p 9)

MPT has asked its advisory body, the Telecommunications Technology Council, to formulate policy on technical development and standardization in the area of multimedia communications and broadcasting. Three issues have been raised: (1) technical problems relating to networks which merge communications and broadcasting, (2) the need to formulate basic policy on standards, and (3) policies to promote advanced technical development. The council is scheduled to complete its report on these issues in May 1995. (Tokyo DEMPA SHIMBUN 28 Jun 94 p 2, Tokyo NIKKAN KOGYO SHIMBUN 28 Jun 94 p 11)

Fujitsu has developed a technique for forming silicide on gate, source, and drain electrodes of MOS FETs using nickel. Called salicide, the new technique first creates a nickel film through vaporization on a silicon substrate with a stripe pattern made of silicon oxide film and then forms a nickel silicide layer through a heating process at 400 deg C. The company claims that the silicide made of nickel achieves a resistivity of 14 microohms/cm; silicide made of titanium or cobalt has a resistivity of 16-18 microohms/cm. The use of nickel in silicide formation is expected to help lower the resistance of electrodes. (Tokyo NIHON KOGYO SHIMBUN 29 Jun 94 p 8)

Toshiba has developed a prototype system for precisely setting the gap between a substrate and an exposure mask. Designed for use in next-generation LSI production which uses X-ray lithography, the prototype uses optical interference to achieve a precision of less than 0.1 micron. It is capable of randomly set the gap at 0-50 microns, and does not move a mask and a substrate to measure it. (Tokyo NIKKEI SANGYO SHIMBUN 29 Jun 94 p 5)

Sanyo Electric has developed a technique for supplying a micro-machine with energy by attaching a photoelectric converter to the machine. The converter integrates 285 optical electromotive force generators, each of which measures 0.5x2.0mm, on a 1.0x1.0cm substrate in

three layers. The converter is about 0.1mm thick. Capable of generating electricity in the same way solar batteries work, the generator has a thin amorphous silicon layer sandwiched by two electrodes and can generate 0.6-0.9V. Since all the generators are connected serially, the converter can generate over 200V when exposed to light. The development of the non-contact photoelectric energy supply technique was commissioned to SANYO by the Micro-Machine Center through a MITI-initiated project. (Tokyo NIKKEI SANGYO SHIMBUN 30 Jun 94 p 1)

NHK Science & Technology Research Laboratories have developed a technique for storing 100Gbytes of data on a 3.5-inch magneto-optic disk. The wavelength multiple recording technique uses for a recording film material a spiropyran dielectric with a recording sensitivity corresponding to each oscillation wavelength of multiple lasers, which permits multiple data to be recorded on the same spot. In an experiment, the labs succeeded in multiple recording using two light sources, a 600nm dye laser and a 488nm argon ion laser. (Tokyo KAGAKU KOGYO NIPPO 30 Jun 94 p 13)

The MPT Communications Research Laboratory's Kansai Research Center has developed a superconductive thin-film device capable of receiving 600GHz signals, nearly three times as sensitive as other devices that have been developed. The SIS-structured (superconductor-insulator-superconductor) device has a 2nm-thick aluminum oxide insulating layer, an equivalent of 20 atoms, placed between niobium nitride layers and operates at -269 deg C. The device is expected to be used in such applications as a radar observing the ozone layer and a radiotelescope for observing interstellar gases. (Tokyo NIKKEI SANGYO SHIMBUN 1 Jul 94 p 5)

MPT is preparing to restructure its Telecommunications Policy, Telecommunications, and Broadcasting Bureaus as the integration of communications and broadcasting services is increasingly becoming a reality of the future. Although an official admits that "it is going to be very difficult to restructure our organization," another points out that the current organization is not fit to meet today's demand. He questions, "Once a cable TV business obtains a common carrier license, do they come under the jurisdiction of the Telecommunications Bureau?" Problems are already arising as to who should be in charge of which service. For instance, charges for satellite communications service are approved by the Telecommunications Bureau's Data Department, while the Broadcasting Bureau's Satellite Broadcasting Department is in charge of communications satellite-based broadcasting. (Tokyo NIKKAN KOGYO SHIMBUN 1 Jul 94 p 11)

Fujitsu has introduced a parallel computer priced below 20 million yen (\$202,020). An entry model in Fujitsu's AP1000 series of massively parallel supercomputers, the AP1000C can be equipped with 4-64 25MHz SPARC or 50MHz SuperSPARC RISC (reduced instruction set

computer) processors and 4Gbytes of memory, and is capable of achieving a processing speed of 3.2gigaFLOPS (floating point operations per second). While installation space has been shrunk to about 1/3 that of AP1000 models, cost performance has been increased by 30%. The minimum configuration four-processor model with 64Mbytes of memory delivers a performance of 200megaFLOPS and lists at 12.5 million yen (\$126,263). Shipment is slated for December. Targeting university and small research labs, Fujitsu is aiming to ship 20 units over two years. (Tokyo NIKKAN KOGYO SHIMBUN 4 Jul 94 p 9)

Mitsubishi Electric has developed a NOR flash memory cell erase technique conducive to lowering the read operation voltage. The technique first applies erase pulses to memory cells to lower the voltage level of programmed cells below the threshold (read) voltage, and then restores excessively erased cells through recovery programming. This process narrows the erased cells' word-line threshold distribution and helps lower the threshold voltage while maintaining the erase time almost as short as conventional methods. The company fabricated a test device using 0.5-micron technology and confirmed that the device operated at a read voltage of 2.5V. (Tokyo KAGAKU KOGYO NIPPO 4 Jul 94 p 11)

Sharp has developed 8.4- and 10.4-inch thin-film transistor color LCDs which cut power consumption by 20-30% over conventional models, and plans to launch volume production within the year. The 8.4-inch model consumes 1.9W, down 30% from its predecessor, and the 10.4-inch unit requires 2.9W, down by 0.7W. Both models use only one cold-cathode tube for a backlight unlike conventional LCDs which require two. Other improvements are an increase in the TFT substrate's aperture from 53% to over 60% and an increase in transmissivity of a color filter and a polarization plate from 5% to 7%. They have contributed to considerable power saving while the new models maintain brightness at about the same level as conventional models. SHARP plans to start producing 30,000 units each of the new models monthly at its Tenri plant. (Tokyo NIKKEI SANGYO SHIMBUN 4 Jul 94 p 1)

### Japanese S&T Developments Reported

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NEC has developed a high-speed FET with a gate length of 0.1 micron. The new FET is made through selective deposition and impurity doping and is reportedly 50% faster than conventional high-speed FETs. Boron is implanted into a silicon substrate at 300keV to form a layer 1 micron deep from the surface, and boron fluoride ions are implanted at 10keV to form a high-concentration impurity region 50nm deep from the surface. The substrate then goes through ultra-high-vacuum chemical vapor deposition to grow a 40nm-thick silicon layer, on which a gate electrode is created. NEC expects the new FET to pave the way for development of a 4Gbit DRAM. (Tokyo NIKKEI SANGYO SHIMBUN 5 Jul 94 p 5)

NKK, in conjunction with an affiliated company, has developed a metal-shielded optical fiber-based immersion thermometer capable of measuring melted steel temperatures of 1,200-1,800° C. The Fimtherm-M dips the tip of the metal-shielded optical fiber in melted steel to measure the temperature. The new thermometer requires 1/3 the cost of a platinum thermocouple-based thermometer and takes 1/10 the measuring time. A manual measurement model costs from 2 million yen (\$20,202), with NKK aiming for first- and second-year

sales of 100 million yen (\$1.0 mil) and 300 million yen (\$3.0 mil), respectively. (Tokyo NIKKAN KOGYO SHIMBUN 5 Jul 94 p 15, Tokyo KAGAKU KOGYO NIPPO 5 Jul 94 p 9)

Sanyo Electric has developed a parallel data processor which is used with a workstation to boost computing capability. To be put on the market by the end of July, the CyberFlow carries out 3-D computer graphics computation for the workstation. It measures 30x67x54cm. Its computing capability does not match that of parallel computers, but the installation cost is estimated at about 30 million yen (\$300,000), substantially lower than installing a parallel computer. The CyberFlow is equipped with 64 CPUs and can execute a maximum of 640 million instructions per second. (Tokyo NIKKEI SANGYO SHIMBUN 6 Jul 94 p 1)

Sanyu Electronics has developed a YAG (yttrium aluminum garnet) laser processor which uses a semiconductor laser as an excitation light source. The laser has a wavelength of 266nm,  $\frac{1}{4}$  that of conventional devices, and therefore the SLM-700 can reduce a focal point diameter to 1 micron. Since the light absorption rate of an object which is processed, the laser processor requires as little as 0.1W to process. Unlike conventional processors which use an excimer laser, the SLM-700 does not require gas refill and uses a simplified laser cooler. As a result, running costs are slashed to less than 1/10 those of conventional systems. The desktop laser processor measures 90x31x22cm and is priced from about 10 million yen (\$100,000). Targeting universities and research institutions engaging in micro-machine technology development, SANYU is aiming to ship 10 units the first year. (Tokyo NIKKEI SANGYO SHIMBUN 6 Jul 94 p 1)

MATSUSHITA ELECTRIC has developed an IC mount technique, which makes it possible to connect chips to electrodes on a substrate in a 100-micron pitch. The technique helps replace defect chips easily and is characterized by two-step bumps which can be created on aluminum electrodes using conventional wire bonding systems. Since the company is receiving inquiries from other firms, it may decide to license the technique in fiscal 1994. (Tokyo DEMA SHIMBUN 6 Jul 94 p 1, Tokyo NIKKAN KOGYO SHIMBUN 6 Jul 94 p 7, Tokyo NIHON KOGYO SHIMBUN 6 Jul 94 p 9, Tokyo NIKKEI SANGYO SHIMBUN 6 Jul 94 p 8, Tokyo KAGAKU KOGYO NIPPO 6 Jul 94 p 9)

NEC has developed a round-edged single-mode optical fiber (SMF) featuring twice the coupling efficiency of previous SMFs. The tip of the core, through which light travels, is spherically processed to provide the SMF with a lens capability. A smooth spherical surface is made possible by using etching and electric discharge heating processes. The new SMF achieves a coupling efficiency of 60% while slashing the production cost to 1/5 that required of conventional microlens-based SMFs. The company expects the new optical fiber to cut optical network system costs in the future. (Tokyo NIKKAN KOGYO SHIMBUN 6 Jul 94 p 6)

Toshiba has developed a micro-filter CRT which features both high resolution and high luminance. The new CRT uses red, green, and blue micro filters, which are attached to the corresponding luminescent materials, to effectively increase the luminance. The micro filters also prevent unnecessary external light from entering the luminescent surface to increase the contrast. In addition, the micro-filter CRT consumes less power than conventional CRTs to achieve the same luminance. As the new CRT can be used for both PC monitors and TV receivers, Toshiba defines it as a strategic multimedia product and will start producing 100,000 units a month next spring. (Tokyo NIKKEI SANGYO SHIMBUN 7 Jul 94 p 1)

Fujitsu has developed an excimer laser lithography resist for 256Mbit and 1Gbit DRAM production. It is expected that 248nm KrF (krypton fluoride) laser will be used for 256Mbit DRAMs requiring a linewidth of 0.25 micron and that 193nm ArF (argon fluoride) laser will be used to print 0.2-micron or finer patterns to produce 1Gbit DRAMs. The new resist is a copolymer with an optical transmittance of 55%/micron. Fujitsu has succeeded in creating 0.17-micron patterns using the ArF laser and the new resist. (Tokyo NIHON KOGYO SHIMBUN 7 Jul 94 p 6)

Toshiba has developed the industry's smallest SAW (surface acoustic wave) filter measuring 3mm square. Designed for use in the RF stage of a mobile phone, the new filter is made using a lithium tantalate substrate and takes 40% less space than a 3.8mm-square filter, which has been the smallest to date. It supports most of the mobile phone communications formats including the U.S. AMPS, European GSM and ETACS, and Japanese NTACS and PDC. Toshiba Hokuto Electronics plans to start producing 20,000-30,000 units a month by year end. The RF stage-use SAW filter market is now dominated by FUJITSU with nearly a 70% market share. (Tokyo KAGAKU KOGYO NIPPO 7 Jul 94 p 9)

Sumitomo Chemical has developed an LCD panel phase-differential film with an angle of field almost comparable to that of a CRT. The phase-differential film, which the company wants to put on sale within the year, uses an LC polymer, which gives the film LC functionality. Sumitomo has also developed a polarization film highly durable for outdoor use. It has confirmed that the polarization film can withstand 105°C heat for 1,000 hours. The film is mixed with a special paint, instead of iodine which is used with conventional polarization films, which the company developed with a paint company. (Tokyo NIKKAN KOGYO SHIMBUN 8 Jul 94 p 1)

Toshiba has fabricated a porous silicon capable of emitting electroluminescent (EL) light as efficiently as a GaAsP (gallium arsenic phosphide) LED. Toshiba's porous silicon is coated with 1nm-thick oxide film and emits 700-750nm light at a current injection of 20mA per sq. centimeter, achieving a light emitting efficiency

of over 0.1%, as high as that of a GaAsP LED. Although researchers are moving ahead with development of porous silicon-based EL panels targeting automotive meter panel and computer display applications, difficulties in developing thin-film luminescent materials and improving the luminance have delayed the implementation of such panels. (Tokyo NIHON KOGYO SHIMBUN 8 Jul 94 p 8)

#### MITI Announces Policy, Target for Fuel Cell Development

94FE0808A Tokyo KAGAKU KOGYO NIPPO  
in Japanese 9 Feb 94 p 12

[Text] The Ministry of International Trade and Industry (MITI) has announced its policy and target for the development of next-generation fuel cells beyond the year 2000. These cells include the molten carbonate fuel cell (MCFC), the polymer electrolyte [or alkaline] fuel cell (PEFC) and solid oxide fuel cell (SOFC). The focus of development will be the MCFC, which the electric power industry has chosen as its primary candidate to replace conventional power plants, and the existing PEFC, which will be used by public utilities that provide localized service to cities. MITI expects that the SOFC will be next in line after the MCFC as the alternative to conventional power plants, and that the PEFC will be limited to small-scale public utilities and mobile use.

The policy plans for the MCFC to be used to replace conventional power plants of the several ten to several hundred thousand kilowatt class. The MCFC is most suited for large-scale systems when the utilization of exhaust heat is taken into account because it operates at a higher temperature (680°C) than phosphoric acid type fuel cells. The MCFC will be used for several ten to several hundred thousand kilowatt class power plants, but because of costs and other considerations, the timeframe for its utilization is expected to fall at the start of the 21st Century, and initially it will use LNG for fuel.

The targets for future development call for verification testing to proceed at a 1 megawatt class pilot plant through 1997, and research to begin at a 5 to 10 megawatt class demonstration plant in 1998. Research on commercialization will be conducted by the private sector during these same time periods.

Technical issues include:

- (1) extending the life of the fuel cells (to last 4-5 years),
- (2) improving fuel cell performance (by increasing current density),
- (3) reducing costs,
- (4) making the fuel cells lightweight.

The PEFC is currently at the stage of basic research and has not reached a level at which a timeframe for its utilization can be forecast, but in the U.S. this technology has a well-established track record in small fuel

cells for space and military use, so MITI anticipates moving to commercial use in a relatively short period of time. This fuel cell operates at low temperatures of 100°C or less, and it is easy to use because the electrolyte is a polymer film. It is expected to be widely used by small public utilities (to provide residential power) and as a power source for automobiles (forming a hybrid with batteries).

The SOFC is expected to be used after the MCFC as the alternative to large-scale conventional power plants rather than as a small, decentralized source of energy because it operates at the high temperature of 1000°C. However, because the SOFC requires ceramic electrodes, it may be very difficult from a technical standpoint to make this fuel cell very large. MITI expects to have a clearer perspective on its future use before the year 2000.

Inherently, fuel cells release very little NO<sub>x</sub>, so they are much more environmentally friendly than existing conventional power plants. Moreover, because their waste heat can be effectively utilized, their total energy coefficient is quite high, and they also generate very little CO<sub>2</sub> per unit of energy. Therefore, MITI has adopted a policy of actively utilizing fuel cells at the same time it conducts R&D on them, although it will result in slightly higher costs.

#### Advisory Committee for Energy Revises Target Scale for Fuel Cell

94FE0808B Tokyo KAGAKU KOGYO NIPPO  
in Japanese 13 Dec 93 p 12

[Text] The government has confirmed that the original target for the introduction and proliferation of fuel cells has been rolled back considerably. A report by the Alternative Energy Subcommittee of the Advisory Committee for Energy predicted that the target for the utilization of phosphoric acid fuel cells (excluding the electric power industry) would be 160,000 kW in the year 2000, but these figures are considerably lower than the 1,200,000 kW of power announced in the long-term energy supply-and-demand forecast of June 1990. The primary reason for the sharp downward revision is long-term reliability. In other words, the technical obstacles involved in increased fuel cell life have proved much greater than anticipated three years ago. Fuel cells are expected to be used for co-generation in decentralized power sources, but a definitive forecast for technical development is needed.

The target of 160,000 kW was not included in the public release of the report, but it was calculated based on projections by the New Energy and Industrial Technology Development Organization (NEDO) and others in reviewing the scenario for the introduction of fuel cells. The Agency of Natural Resources and Energy has clearly stated: "The 1,200,000 kW target of three years ago has been revised to 160,000 kW." The agency emphasizes the validity of the new figures by stating: "We realize that this number is disappointing when

viewed from the standpoint of actively expanding industries such as electric power and gas, but it was calculated based on predictions by NEDO and others."

The sharp downward revision is a result of problems with fuel cell life. The original target was 40,000 hours (5 years) with cell stacks and improved catalysts, but performance up till now has stalled at 15,000 hours. Another sticking point is that when the cells are made more compact to reduce their cost and their power density is increased, they do not last as long. The record for the longest operation time of 15,000 hours was set in 1987 on a model with a cell performance of 0.08 watts/cm<sup>2</sup>. When cell performance is increased to 0.16 watts/cm<sup>2</sup>, the upper limit for cell life is currently about 10,000 hours. Achieving both high performance and long life is a major problem for technical development.

In the report by the Alternative Energy Subcommittee the target for solar power generation for the year 2000 is 250,000 kW (with 50,000 kW of that for the electric power industry), which is the same as three years ago. In comparison, the downward revision for fuel cells is conspicuous. When asked about this, the Agency of Natural Resources and Energy replied: "If we force the

utilization of fuel cells before we have clear confirmation on how long they will last, the widespread adoption of fuel cells will become increasingly difficult."

Field testing of solar power and fuel cells is subsidized by the government. Two-thirds of the funding goes to solar power and the remaining one-third to fuel cells. Moreover, the fees for the purchase of surplus power by electric power companies that began last year are higher for solar power than for fuel cells. The explanation for these disparities is that "the commercialization of fuel cells is close at hand," but that reasoning is mistaken. There is also the view that "the electric power industry is enthusiastic about solar power but indifferent toward fuel cells." This opinion is also off base because the targets of three years ago were the figures from the Electric Utility Industry Council.

Because it has become evident that the commercial use of fuel cells is not close at hand, it will likely be necessary in the future to adopt a policy of increasing the plant subsidies for fuel cells to two-thirds of the total and making the option price of surplus power from fuel cells the same as for solar power.

### **JGC, KHI, Sumitomo Corp. To Build Antipollution Plant in Czech Republic**

43070106A Tokyo JAPAN CHEMICAL WEEK  
in English 5 May 94 p 8

[Text] JGC Corp., a major Japanese plant engineering firm, will build an antipollution plant in the Czech Republic for a local thermal plant, in co-operation with Kawasaki Heavy Industries Ltd., and Sumitomo Corp.

The company will construct a plant to extract sulfuric acid—the cause of acid rain—from the exhaust gas of Elektrárny Opatovice A.S., a Czech thermal plant situated 100 km from Prague. The new plant based on Kawasaki's lime-gypsum process is expected to treat 2,142,000 Nm<sup>3</sup>/h of flue gas.

The thermal plant will pay ¥6 billion (\$57 million) for the project, using loans from the Export-Import Bank of Japan.

The former communist nation is making antipollution measures mandatory for its industries to fight the country's serious air pollution, with an eye to joining the European Union.

JGC is moving to receive similar orders from other thermal plants in the Czech Republic and neighboring East European countries.

### **Thin Film Devices**

94FE0546A Tokyo SEMICONDUCTOR WORLD  
in Japanese Apr 94 pp 89-100

[EXCERPTS]

#### **Glass Substrate Standardization and Substrate Inspection**

(Katsuhiko Shintoh, Corning Japan, Quality Assurance Division)

#### **Introduction**

The rapid expansion of the Liquid Crystal Display (LCD) market, especially for active-matrix type LCDs, is continuing. The size of non-alkali glass substrates, which are used for active-matrix LCDs, is growing yearly, and the volumes shipped of the same are certainly growing. This trend will probably continue in the future. If the production of LCDs, not only in Japan but overseas as well, continues to expand, it seems that dealing with the issue of standardization will become even more important.

The first issue that is raised in connection with glass-substrate standardization is that of substrate size. There have been many debates over this issue in the past, but it is difficult to say that a consensus has been adequately obtained. Active-type LCDs range from small, less than an inch in size, to large, over 10 inches. One of the main reasons that problem has become so difficult is that there is no standardization for even LCDs which are to be used

for the same purpose. Another problem is that the industry across the board, including glass makers and equipment manufacturers, have not grappled adequately enough with the issue of standardization.

#### **Large-Sized Glass Substrates**

When the first factory to mass-produce active-type LCDs started operation, it produced substrates with a 6-inch diagonal size. However, the product that is mostly produced now is the 9 to 10-inch LCD display, which is composed of two substrate plates (for example 300 X 400 mm or 320 X 400 mm). Furthermore, starting in late 1993 and moving into 1994, several LCD makers were presented with lines that they could invest in which could produce glass substrates that could be used in four-plate type substrates. In the future, it is possible LCDs from 9 to 10 inches will use glass that can be joined into 6 or 8-plate substrate size.

From the point of view of the glass-substrate makers, even though they have been able to respond to the demand for various sizes up to the 2-plate size without standardization, some type of uniformity for sizes larger than this is necessary. The reasons for this are as follows:

1. Glass substrates are created to a certain width through a process of fusion formation. This glass is then cut, beveled, washed, and inspected before it is shipped (after this it is polished by the glass maker). Most of the processes and facilities needed to produce the larger sizes, especially those larger than the 6-plate size, would need to be reconfigured. For example, with a size difference of 10 mm, glass makers would have to reconfigure their equipment. Furthermore, the many merits of standardization come to mind when one considers the automation involved in processing, as well as the packing required for shipping.
2. Currently, a majority of the appearance inspections of the glass substrate surface, including those for damage or contaminants, are carried out visually by the inspectors. However, there are limits to the current method when applied to the larger sizes. The introduction of larger sizes would accelerate the rate of transition over to automated inspection systems. The necessity to unify sizes will probably go along with the level of automation.

#### **The Standardization of Appearance Inspections**

Currently, the primary method of inspection of the glass substrate surface for contaminants or damage is visual, utilizing a high-intensity light source. However, differences occur based factors such as the light source used (for example, parallel light or fractionated light, halogen light, mercury light, florescent light, white light etc.), environmental conditions during the inspection (light or dark etc.), inspection method (reflection, penetration, oblique light, etc.), duration of the inspection, and the skill level of the inspector. If inspection methods differ, then the acceptance inspections by the LCD makers will not match the standards used by the glass makers.

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Considering the future adoption of automated inspection methods, even with such automated measures, unless there is sufficient consultation with the users, there will probably arise a situation where the standards adopted by the glass makers and the LCD manufacturers will not match. Therefore, along with the development of automated inspection technology, it is also important to deal with the issue of standardization.

#### Grappling With Standardization

With regard to the items to be inspected/measured connected to glass-substrate standardization, along with the items already mentioned, several things come to mind, including evenness (curving, undulation), substance resistiveness, and thermal compression.

As far as the writer knows, there are a few groups working toward LCD glass substrate standardization. These are SEMI, EIAJ, and the New Glass Forum (there seems to be a certain degree of information sharing between these groups). The following are the glass standards which are being discussed in the SEMI Standards Committee:

1. Extent of Front Panel Display (FPD) substrate effectiveness
2. FPD substrate standard size
3. Definition of FPD substrate terminology
4. FPD substrate surface coarseness measurement method (under consideration)
5. FPD substrate substance resistiveness testing method (under consideration)
6. FPD display edge condition (under consideration)
7. FPD display undulation measurement method (under consideration)

The proposals on extent of substrate effectiveness and on edge condition were made by the American committee, but the remainder of the proposals were presented from the Japanese side. There are several companies, starting with my own, who are making glass substrate for active matrix LCD displays, and the glass from each of those companies differs in composition, fabrication procedure, and processing method (see Figure 1). Therefore, each of the makers probably are facing different problems. Furthermore, the inspection methods and measurements used by each of the companies are not unified. In the future, it is hoped that the debate on standardization, including participation from glass makers and LCD makers, will become more active.

#### Reference Documents

- (1) Bokuno: Latest Trends in Glass Displays, 1994 New Developments in LCD Technology, Monthly Semiconductor World Expanded Edition (1993.10) p. 227

- (2) H. Amemiya: The Production and Properties of Glass Substrates for LCDs, 3rd International Conference on Advances in Fusion & Processing of Glass (1992)

- (3) Wada: New Trends in TFT Glass Substrates, The Second Fine Technology Japan Specialized Technology Seminar Text (1992)

#### LCD Panel Light Inspection Technology

(Yoshihiro Hirai, Japan Micronics)

##### Introduction

The early phases have ended for the liquid crystal industry, which is preparing for a era of full-scale mass production. As part of this trend, light display inspection equipment has also developed because such equipment is expected to become indispensable with regarding to the improving of production capability. Up until now, the inspection of LCD panel picture quality was carried out visually, however, because there is a great need for automated inspection, it is possible that automatic inspection will be promoted in the future. With the adoption of automatic inspection, it can be said that probe technology used with the light display will become increasingly important.

This article will discuss LCD cell light display technology, which is used in the inspection of LCDs and which was developed based on probe technology nurtured by our company for semiconductor inspection, as well as the applications of this technology.

##### LCD Panel Light Display Inspection Technology

An LCD cell inspection system is based on the following basic configuration (Figure 1):

- (1) Light Display Equipment (prober): probe unit, back light with X Y Z  $\theta$  stage, auto alignment, autoloader
- (2) Signal Control Unit: system controller, signal processing circuit, drive circuit
- (3) Cell Tester: camera controller, image processing equipment, personal computer (PC) keyboard, display

##### 1. Special Characteristics of the Light Display Equipment

When the assembly of an LCD cell is completed, it is caused to display an image, and the quality of that image is tested (Figure 2). The cell light inspection is the most important one, because the LCD panel is the element of a display that is viewed directly. The picture quality test is carried while all of the scanning electrodes and signal electrodes, which are installed near the cell, are probed. In other words, the inspection is done by sending a picture and test pattern to the LCD cell. It is important that the display conditions at the time of the test are as close as possible as the ones that will exist when the LCD panel display will be when in actual use. The following is

Glass Code	Type	Chemical Composition				Distortion point (°C)	Thermal Expansion Coefficient (ppm/°C)
		SiO <sub>2</sub>	B <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	RO		
Corning 7059	Non-Alkali Glass	49	13	10	25	592	4.5 (0-300°C)
NH Technoglass NA45 <sup>1</sup>	"					610	4.5 (100-300°C)
Asahi Glass AN <sup>2</sup>	"	56.3	4	11	26.3	625	4.3 (50-250°C)
Corning 1733	"	57	12	15	14	640	3.65 (0-300°C)
NEG OA-2 <sup>3</sup>	"	56	6	12	24	645	4.7 (20-380°C)

Figure 1. Different Methods Used By the Various Glass Makers

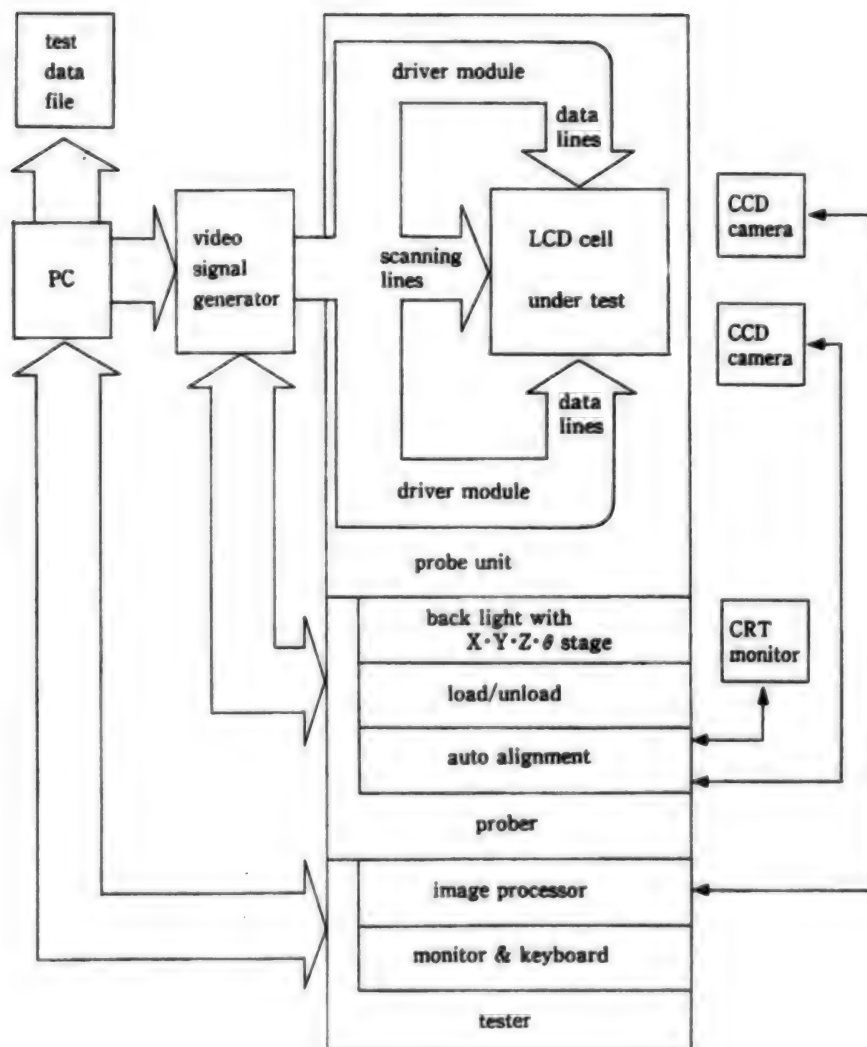


Figure 1

Key: 1. LCD Cell Inspection System Block Diagram

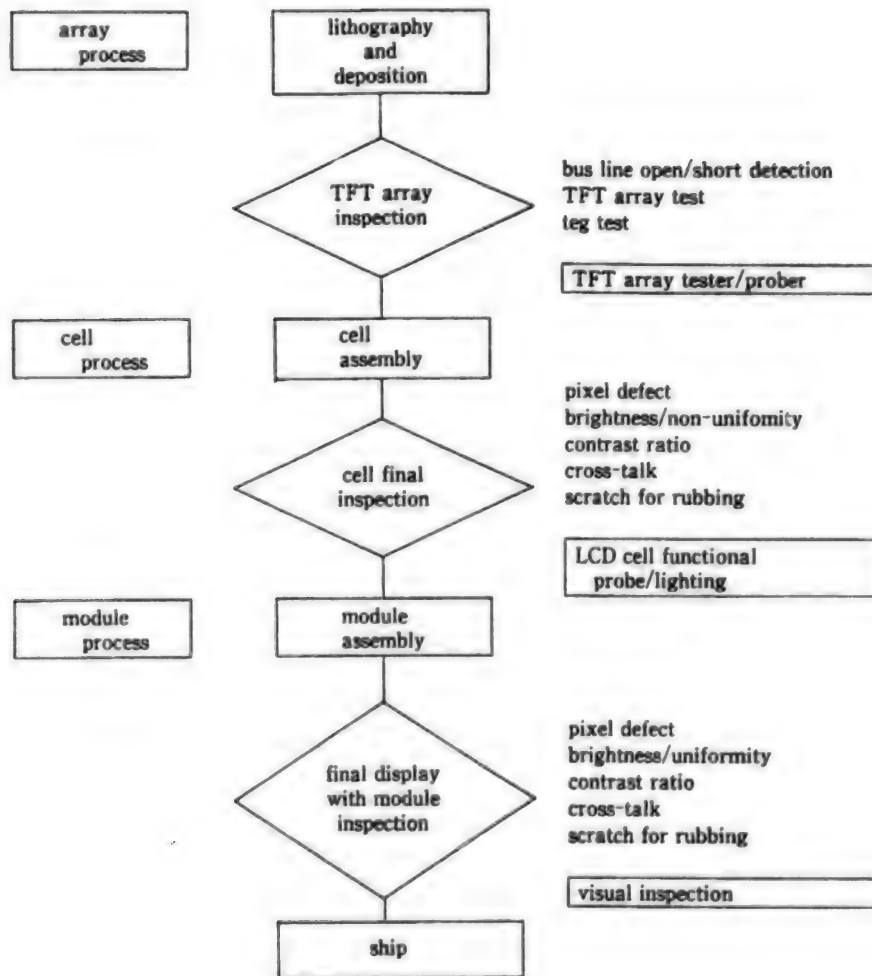


Figure 2

Key: 1. LCD Production Flow

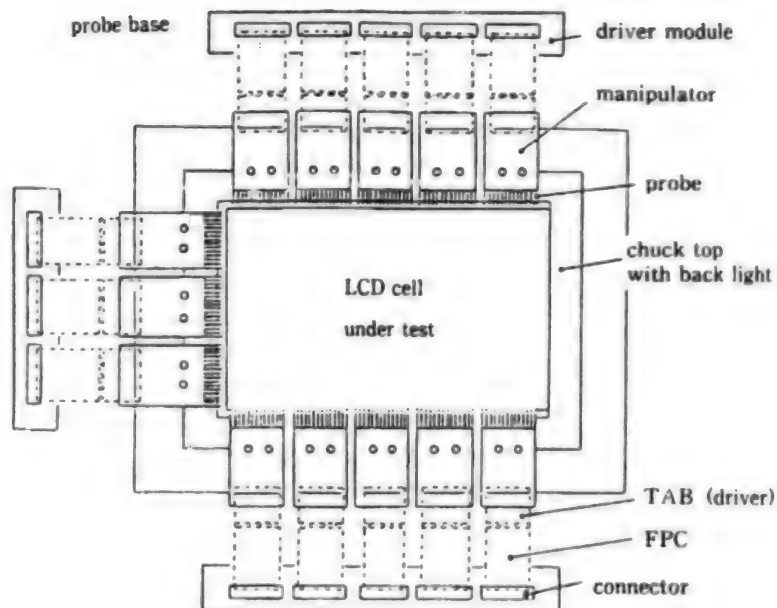


Figure 3. Probe Unit (illustration)

a list of the special characteristics possessed by our company's light display equipment:

(1) Probe Unit (Figure 3, Figure 4)

1. It can probe all of the cell's electrodes at the same time
2. Because of the proximity of the driver IC and the probe, it can display with the same picture quality as the display condition at completion
3. Because a needle-type probe is utilized, it can be used even for high-resolution, high-detail cell electrodes, and it can achieve long-life, highly reliable probe contact (lifespan of over 1 million contacts)
4. The probe has excellent maintainability because it is installed on the driver's TCP position with a manipulator
5. Because it uses needle-type probes, the display equipment's field of observation is wide

(2) Auto Alignment

1. Because alignment is carried out at the probe contact point, it is not effected by steady movement errors, and it is able to carry out high speed, high resolution probe alignment (precision: plus or minus  $\mu m$ )
2. Very stable alignment is possible because two alignment cameras are included in the probe unit

(3) Chuck top/Backlight

1. Stable vacuum adsorption can be carried out on curved plate displays as well

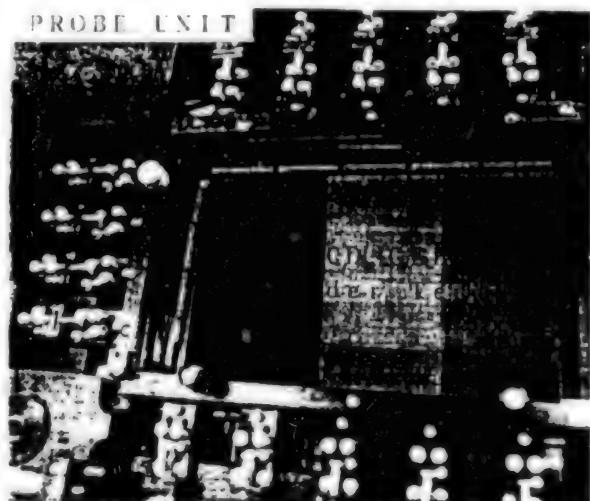


Figure 4. Probe Unit (photograph)

2. Stable chucking is achieved by a load of 2,400-5,000 probes
3. In the models installed with a backlight, when necessary, a polarized light plate can be installed
- (4) Auto Load

1. Transportation robot: flexibility is maintained towards various types and sizes of cells and cassettes through use of a direct-drive transportation robot

2. Relay plate: pre-alignment is carried out while the cell plate is brought from level to an angle

3. Change arm: the changing of the test-completed cell and the yet-to-be-tested cell is done at the same time (twin-arm type)

4. Cassette deck: this unit has the capability to accommodate removable cassettes or fixed instructions. It also has communications for automatic transportation equipment (AGV) and therefore is able to carry out unmanned cassette placement operations

#### (5) Equipment Expandability

1. It has the responsiveness to be able to allow it to read the identification numbers of the cassettes and cells

2. It is possible to install an interface that would allow the unit to be connected to automatic picture quality inspection equipment

#### 2. Capabilities of the Lighted-Display Equipment

LCD panel displays are high resolution, high precision, full color instruments that have had their module functional electrodes reduced in number from 4 to 2, and which possess an expanded effective display size. Corresponding to this, a higher level of probe technology for light displays is demanded. It is not exaggerating to say that probe technology is the key technology for light displays.

##### (1) Probe Functional Precision

Table 1 shows that pitch and width used by TCP functional electrodes. Because the length of the TCP electrode is relatively long, 2-3 mm, the probe's arrangement has freedom in areas such as irregular alignment. However, in the case of COG functionality, an inspection pad is required.

However, pads the length used by things such as TCP are not made, and therefore, because of their extremely small size of 100-200  $\mu\text{m}$  and also their continuous pitch arrangement, a high-level probing technology is required. The needle probe excels in this regard (Figure 5).

##### (2) Probe Contact Reliability

Ensuring probe contact reliability is an especially important item. It is important to completely understand the cell device conditions (things such as pad size, electrode surface oxidation, soiling, materials quality, and warping). It is hoped that it will be possible to distinguish between events such as failures caused by bad contact because of soiling, missed contact, and bad cells.

##### (3) Signal Circuit Electrical Characteristics

It is important to keep the circuit as short as possible in order to make it conform to a transmission signal of greater than 100 MHz.

##### (4) Static Electricity Countermeasures

表1 プローブの実装密度 (1)

	(2) 画素数	(3) パッドサイズ( $\mu\text{m}$ )	(4) プローブシステム	
			プローブ数 (5)	プローブピッチ( $\mu\text{m}$ ) (6)
VGA	640 × 480	~100	2400 + $\alpha$	~150
XGA	1024 × 768	~66	3840 + $\alpha$	~110
S-XGA	1280 × 1024	~60	4864 + $\alpha$	~100

Table 1

Key: 1. Probe Functional Precision; 2. Pixel Density; 3. Pad Size ( $\mu\text{m}$ ); 4. Probe System; 5. Number of Probes; 6. Probe Pitch ( $\mu\text{m}$ ).

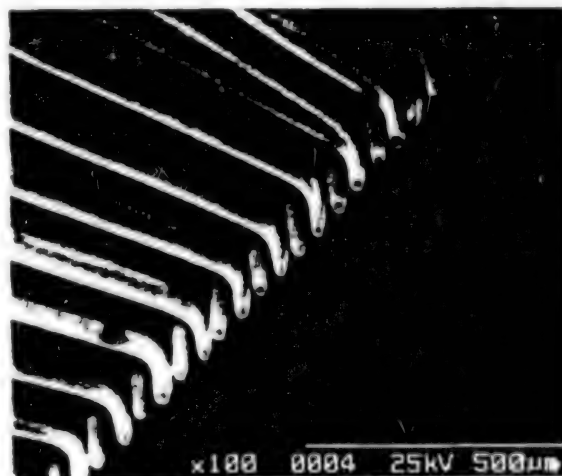


Figure 5. Needle Probe (60  $\mu\text{m}$  pitch)

Because its electrode terminals are in an open condition, LCD cells are left in an almost defenseless position with regard to static electricity. It is particularly important to consider the prevention of damage from static electricity during cell handling.

##### (5) Cell Product type Changeability

It is necessary that product types can be changed safely in a short period of time.

#### 3. Probing Technology

Considering the element technology needed by the lighted display equipment, the following items emerge (Figure 6):

(1) Probe Contact Efficiency: probe pitch, probe advanced diameter, probe position accuracy

(2) Special Electrical Qualities: contact resistance, the effect of soiling etc., special characteristics of the signal circuit frequency

(3) Lamp Observably (Figure 7): the angle of the inspection field of view, angle of cell inclination

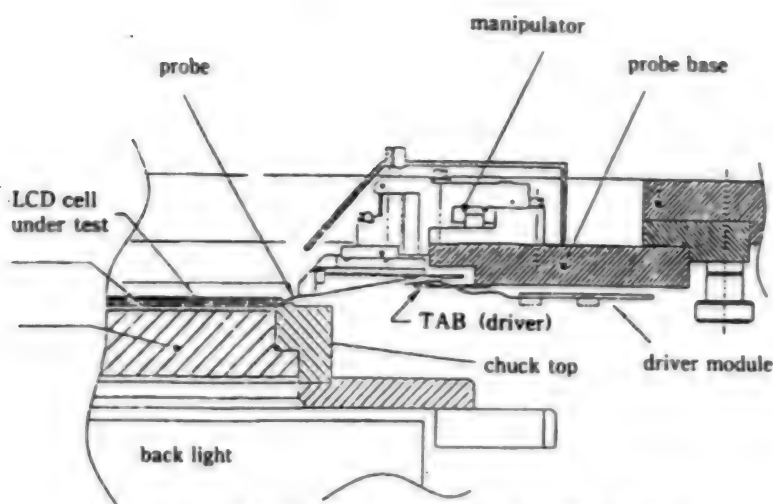


Figure 6. Probe Contact (cross-section illustration)

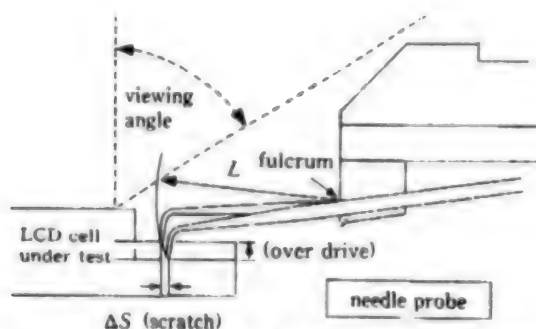


Figure 7. Needle Probe Structural Characteristics

(4) Operability/Maintainability: operability during periods of cell product type change, the ability to confirm probe contact, probe unit maintainability

(5) Switchover Time: high-speed transportation

#### 4. The Connection between Automatic Picture-Quality Inspection Equipment and Lighted Display Equipment

There are two types of cell picture quality inspections: human visual inspection and scientific automated inspection supported by image processing technology.

Up until now, most of the cell picture quality inspections have been carried out by human inspectors. The main reason for this was the exceptionally superior capability that the human eye has to confirm picture quality. A skilled inspector can carry out a subtle quality inspection in a short period of time. Furthermore, it can also be said that another reason for this was that the automatic inspection equipment that has existed up until now, which must be judged based on the standard of the human eye, lacked adequate mechanisms for light and color sensitivity.

However, because visual inspection relies on individual ability, inconsistencies can arise because of differences between individuals and continuous operation. Therefore, no objective data could be obtained, and the standards applied are ambiguous. Furthermore, quantitative standards are difficult to set. Because of this, judgements change, and it tends to exert an influence toward halting progress. There is a strong desire for the quantitative management of, and easy inspection of, panel quality.

Recently, there has been remarkable progress in the areas of image-acquisition and image-processing technology, and equipment has been developed which, depending on the item to be tested, is superior to the human eye.

Gradually, in the future, automatic test equipment will enter into testing, and eventually a fully automatic inspection system will be completed. For the time being, however, because visual test will continue and evaluations of the correlation with automatic systems will take place, light display systems which can change between visual and automatic inspection methods will be necessary. Figure 8 and Figure 9 [not reproduced] show such a system.

#### Conclusion

Regarding the conversion from visual to automatic inspection of LCD cell picture quality, it is not just a matter of automatic picture quality inspection technology, but probing technology must be advanced as well. It goes without saying that the stopping of progress caused by an inspection mistake must be avoided. Therefore, an inspection method is required which can distinguish between a true defect and a temporary bad light caused by something such as soiling. In order to improve inspection reliability, joint work between panel makers and equipment manufacturers is very significant.

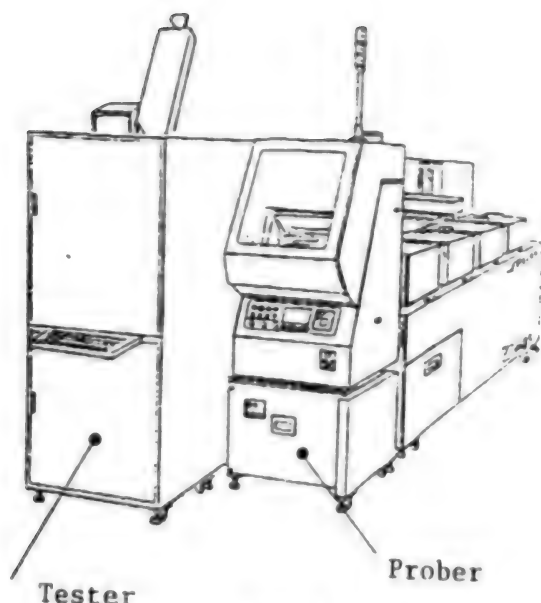


Figure 8

Key: 1. Illustration of Panel Light Inspection System LFP-1100 (with tester); 2. Tester; 3. Prober.

### LCD Picture Quality Evaluation Technology

(Japan Electronic Materials Manufacturers Association: Measurement Technology Division)

#### Introduction

LCDs, which began as numerical displays for devices such as watches and calculators, have developed to

where they are now used to display television images. Currently, they are being put to use as high-resolution displays for computers and office automation equipment. Because of this, LCDs themselves, at both the mass-production and development stage, are put through various stringent capability evaluation examinations. Chief among these are the active characteristic test, the reliability test, and the appearance test. Furthermore, Japanese Industrial Standards (JIS) have been established for LCDs, among which are the "General Rules for Liquid-Crystal Display Panels" (JIS-7071), and the "Liquid-Crystal Panel Display Measurement Standard."

This article will discuss the fundamental picture quality evaluation method and related evaluation equipment (Japan Electronic Materials Manufacturers Association's JCI-30 (Figure 1) [omitted]), and will introduce an example of some of the image testing which can be carried out by this equipment.

#### LCD Picture Quality Evaluation Method

There are four levels in the evaluation of the observed display. These are:

- (1) Measurement of the Physical Radiation Levels,
- (2) Physical Evaluation of Recognizable Factors,
- (3) Evaluation Based on Recognizable Measurements, or Evaluation by Chromographic Measurements,
- (4) Human Engineering Evaluation.

These evaluations test attributes connected to brightness, spectral attributes, and color. Table 1 outlines each evaluation method.

Table 1. Levels of Picture Evaluation their Features and Efficiency Index

	Measurement of Physical Radiation Levels	Physical Evaluation of Recognizable Factors	Evaluation Based on Recognizable Measurements	Human Engineering Evaluation
		(CIE1931 Y, x, y)	Chromographic Measurements (CIE J976 L, a, b)	
Features	A. Radiation Levels	Measurable Light Stimulus Level (Brightness)	A. Brightness L <sup>*</sup>	A. Perceived Brightness
	1. Radiation Flux (W)	Light Flux (lm)		
	2. Radiation Intensity (W/sterad x m <sup>2</sup> )	Brightness (cd/m <sup>2</sup> )		
	B. Separated Light Spectrum	B. Color Level (x,y)	B. Color Level (a <sup>*</sup> , b <sup>*</sup> )	B. Observed Color Level
	1. Light Source	1. Primary Wave Length	1. Hue	1. Hue
Separated Light Spectral	2. Stimulus Purity	2. Tint	2. Tint	
	Intensity P	3. Color Range		
	2. Reflection Percentage			
	Penetration Percentage			
Efficiency Index	C. Efficiency Index	C. Efficiency Index	C. Efficiency Index	C. Efficiency Index

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	1. Radiation Intensity Contrast Comparison	1. Balance RUNANCE [Japanese phonetic Rendering]	1. Color Difference $\Delta E^*$	1. Perceived Contrast
	2. Visible	2. Contrast Comparison	2. Brightness Difference $\Delta L$	2. Error Percentage
	Invisible	3. Color Level Difference	3. Hue	3. Relative Preference
		4. Color Intensity Difference	4. Whiteness	4. Sharpness
			5. Blackness	5. Comfortableness
			6. Color Difference Contrast Rate	6. Feeling of Presence

### 1. Measurement of Physical Radiation Levels

This process does not determine whether the radiation emitting from the screen is visible light or invisible. Here we process visible light.

### 2. Physical Evaluation of Recognizable Factors

The International Illumination Committee (CIE) established a display method (Y, x, y) in 1931. Here we will use Y for luminance, and (x, y) for color level coordinates, giving attributes to each to respond to brightness and color.

### 3. Evaluation Based on Recognizable Measurements or Evaluation by Chromographic Measurements

The quantity  $L^*$  represents brightness in a non-linear (logarithmic) function. Based on perceptual experiments, the function  $L^*$  is defined as follows:

$$L^* = 116(Y/Y_n)^{1/3} - 16$$

While the color level is defined as follows:

$$a^* = 500[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}] \quad b^* = 200[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

In this case,  $Y^*$  represents the luminesce of a perfectly clear, or perfectly reflective, body based on ambient light, and  $Y/Y_n$  represents the relative luminesce. Based on chromographic indexing, the functionality of the display is described as the color difference  $\Delta E^*$ , where  $\Delta E^*$  is defined as follows:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

In a permeable LCD, the highest value of  $\Delta E^*$  reaches 60.

### Human Engineering Evaluation

When a cathode ray tube (CRT) display is nearly completed, it can be evaluated by the recognition period method and by the false reading percentage and comparison method. However, evaluation procedures for devices with complex viewing angle characteristics, such as LCDs, have yet to be adequately established. The easiest of such evaluations, those for contrast and brightness, are the ones used most often for human engineering evaluations.

### The Color Image Monitor Used for LCD Picture Quality Evaluation

The color image monitor JCI-30 is the piece of equipment developed by our company for use in LCD picture quality testing. Specifically, it can evaluate (test) for brightness unevenness and for color unevenness. It is applicable to picture quality evaluation levels 3 and 4 discussed above. Figure 2 shows the configuration of this system.

The fundamentals of the equipment are as follows. First, the subject of the test is imaged by a television camera, the signal output from the television camera is fed to a personal computer. The computer receives the signal through an internal interface board, and the computer receives the signal split into a brightness signal (the Y signal) and a color signal (the C signal). Software in the computer performs the image processing. The brightness display projects an image in light and shade in 256 color gradations. Thus, it can easily show uneven brightness. The color display is divided into hue and tint, and can easily shown areas of uneven color by splitting the 360° of hue into 256 color gradations. Tint also can be shown in the same manner, displayed by density of light and shadow in 256 gradations. All of these displays are presented on the color monitor.

Previously, LCD picture quality examination has been primarily carried out by visual inspection, however, with the development of the JCI-30, inspections can be performed instantly, and quantification has become possible. The LCD fabrication process is divided into three main stages: (1) array fabrication, (2) cell formation, and (3) module assembly. This equipment can fill a primary roll in the testing of cell picture quality. Further, once the cell becomes used in a module, the equipment can also test the picture quality of the module.

Figures 3 and 4 [omitted] present an example of the measurement of uneven brightness in a STN-LCD. Possible causes of uneven brightness in a STN-LCD are (1) variations of the PURECHIRUTO [Japanese phonetic rendering] angle, (2) variations of the thickness of the distribution membrane, and (3) variations in the cell gap. This example shows the measuring of uneven brightness caused by variations in the cell gap. The size of the cell gap is 5  $\mu$ m, therefore an accuracy of plus or minus 0.05  $\mu$ m is required. Figure 3 shows the cell gap as measured by an optical microscope. In figure 4, the

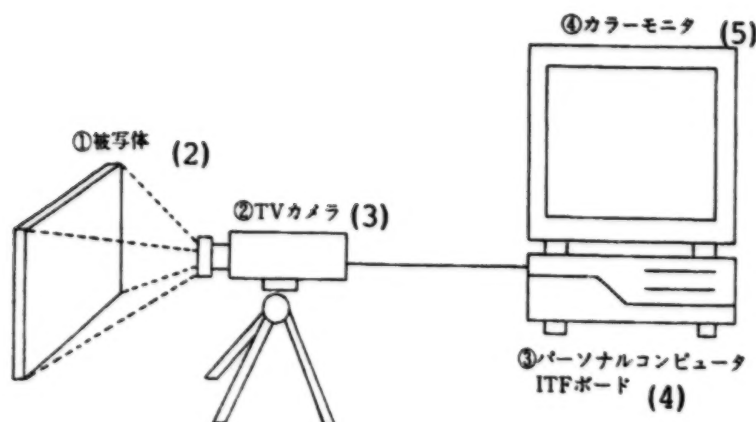


図2 JCI-30構成図 (1)

Figure 1

Key: 1. JCI-30 Configuration; 2. Test Subject; 3. Television Camera; 4. Personal Computer with an ITF Board; 5. Color Monitor.

JCI-30 has performed image processing and is displaying the uneven brightness corresponding to the uneven cell gap.

Figures 5 and 6 [not reproduced] show the calculation of the LCD picture white balance. Figure 5 shows the brightness values on the screen. Figure 6 shows the display of both brightness and the color level index. In this way, both uneven brightness and uneven color can be displayed in a quantified manner.

### Conclusion

In the future, high resolution, low static CCD camera functionality will be required so that this equipment can be used in the testing for defects smaller in size than an LCD picture element. Furthermore, beyond inspection, it will be necessary to solve the optical aberration problem, the problem of viewing angle—which is a

characteristic of LCDs, and the Moire stripe problem. Furthermore, this must not be done based on a visual inspection standard, but a standard needs to be developed for the determining of defects by inspection equipment.

### References

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